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For *Jumanji*—in which jungle animals emerge from a magical board game to wreak havoc on a small town—director Joe Johnston enlisted Industrial Light & Magic and Amalgamated Dynamics to provide computer generated and animatronic effects. *Article by Janine Pourroy.*

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A landmark collaboration between Walt Disney Studios and Pixar has produced *Toy Story*—the first fully computer animated feature-length film—a comic confluence of artistry and high technology directed by John Lasseter. *Article by Rita Street.*

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Production design and physical effects merged to create the vast floating sets and ships needed for *Waterworld*. Voluminous visual effects—overseen by Micheal J. McAlister—kept more than a dozen effects companies swimming. *Article by Jeff Odien.*

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COVER—A jungle board game becomes all too real in *Jumanji*.

BROKEN ARROW: STEALTH EFFECTS

article by Jody Duncan

Indian summer was in full swing and the night air was warm and balmy when crew members from The Chandler Group gathered at the Disney Ranch north of Burbank to film a stealth bomber crash for *Broken Arrow*, the 20th Century Fox action film directed by John Woo and starring John Travolta and Christian Slater. On hand were Chandler Group executive producer Michele Maples, visual effects line producer Kurt Williams, visual effects supervisors Don Baker – who oversaw all of the effects on the show – and Eric Durst, who supervised the crash sequence. There to address the photographic concerns was effects director of photography Tim Angulo.

By the time the crew convened at Disney Ranch, The Chandler Group had already been involved in the film for several months, shooting visual effects elements with the first unit. Production was well underway when Woo and the studio decided that a truly spectacular plane crash would be of benefit to the film; and The Chandler Group was given the assignment. “Originally, they were going to try to do it within first unit,” Maples recalled, “but then they realized they needed someone objective to design the shot and supervise the whole thing, from conception all the way through to delivery.”

The desert bomber crash occurs about twenty minutes into the film, whose plot revolves around a disgruntled pilot who steals a nuclear warhead and holds it for ransom. “This sequence really initiates the roller coaster ride,” observed Maples. “From that point on, the movie is totally action driven, filled with fights and effects.”

While VIFX would contribute twenty-one CG shots of bombers in flight, the crash sequence was done entirely in-camera, with two sixth-scale plane models built by John Stirber, who worked under The Chandler Group umbrella during *Broken Arrow*, and subsequently founded John Stirber Effects. “John did the detailing, the pouring of the fiberglass and the construction of the plane interior to accommodate the way we were going to blow it up,” explained Maples. “It had to be redesigned to some degree, in terms of structure and detailing, to customize it for this particular sequence.”

Constructed of fiberglass over a steel skeleton, each model measured fourteen feet long, with an eighteen-foot wingspan, and weighed about five hundred pounds. “The models had to be built really strong in order to hold up to the action,” noted Eric Durst. “In the scene, the left wing clips a mountain and explodes from the body of the plane. Then, as the bomber crashes, its right wing comes off and the fuselage skids across the desert floor, finally exploding in a big fireball. Both of the wings were breakaway parts made of fiberglass and loaded with debris.”



The company's first order of business, after being assigned the sequence, was to choreograph the crash in a series of animatics. "Eric, Ian Hunter, John Stirber and I built a little desert mock up in the parking lot at Chandler," recalled Tim Angulo. "We had a miniature plane, about three feet wide, and we photographed it in this mockup in video. Eric edited that animatic together to present to Fox, showing how it would work, the different camera angles, et cetera."

The crash of a B-3 stealth bomber in Broken Arrow was achieved in-camera by The Chandler Group using miniatures and pyrotechnics.

"As the movie developed," Durst added, "production people started to realize that the bomber crash could be a real keystone image. Our animatic presentation showed them what was possible. It went well – and I think they saw that it could be a wonderful sequence."

Every aspect of the sequence was planned carefully in preparation for the nighttime shoot at Disney Ranch. One of the challenges faced was the lighting of the bomber model. Storywise, the crash was to take place in a dark, deserted location. Even the self-illumination normally provided by aircraft landing lights was not an option since the crew was shooting what was supposed to be a stealth bomber. "The stealth bomber doesn't have searchlights or landing lights on it," noted Angulo, "so all the lighting had to come, supposedly, from the moon. Since the explosion was what we really wanted to see in this sequence, I exposed to that. I didn't want the lighting to be overpowering."

Five setups were employed for the miniature shoot, each covered by a minimum of five cameras. Serving as the scenic background was a miniature mountain set. "We brought in several truckloads of sand to dress the Disney Ranch to resemble the film's original location," stated Durst. "John Stirber also constructed a miniature rock facade – about twelve hundred square feet, maybe more – made of poured cement. It had to be strong enough to withstand the impact of that plane."



Multiple cameras prepare to record the fiery impact of the cable-flown bomber.

To capture the initial shot of the plane coming into frame, its wing clipping the mountain, the model traveled on a 140-foot-long cable attached to a crane.

"The most difficult part was getting it up to the right speed," noted Durst. "The cameras were shooting at 96 or 120 frames per second – which was the right frame rate for the explosion. That meant that the plane had to move really fast. We experimented a lot to determine the appropriate speeds and angles." The plane was lifted by cable to the top of the mountain mockup, then released. "Once it traveled past the mountain, we had a brakeman stop it so it wouldn't crash into the ground – we needed the body of the plane for the next shot. After each setup, we would do repairs and redetail the model."

Subsequent setups resulted in spectacular footage of the right wing exploding from the fuselage, the airplane skidding across the desert, and then the final explosion. "We used another kind of cable pull for shots of the plane skidding," said Angulo. "We buried a cable, then dragged the airplane along the ground behind a car. It wasn't high-tech, but it was effective."

Pyrotechnic displays occurring throughout the crash were engineered by John Stirber and Roy Downey. Gasoline was used for the primary flame, while primer cord was laid inside the model to assist in the breaking away of the wings. For shots of the burning plane skidding, rubber cement was applied to the ground, producing an impressive trail of fire behind the aircraft.

Despite careful planning and execution, the nature of the sequence mandated repeated takes before each segment of the crash was successfully captured on film. “In any pyro shoot,” said Durst, “the first go-around is just for finding the balances. You use your best judgment in setting things up, but there are always factors you can’t forecast. One of our challenges on this shoot was that we had a limited number of models. These planes were so large and difficult to build, we couldn’t build ten of them and shoot five per night. Everything had to be right on the money; and the plane had to blow up in a very specific way for each shot.”

After the plane crash was completed and cut into the movie, The Chandler Group continued its work on *Broken Arrow*, providing miniature photography for a scene in which a helicopter chases down the film’s love interest, played by Samantha Mathis. Christian Slater’s character comes to her rescue, shooting the helicopter pilot and causing the aircraft to crash. “We were given a foreground plate of the actress running across the desert,” Tim Angulo recalled. “Our job was to shoot a miniature helicopter crash for use as an element with the foreground plate.”

The sixth-scale helicopter model used for the shots was constructed by Larry Jolly, then modified by John Stirber. “It was very thin in the front, so it would crumple when it crashed,” explained Durst. “We mounted it on a pneumatic rig that was angled to make the helicopter come crashing down into the landscape.” The model was shot at 72 frames per second – a rate that required the rotor blades on the model to be motorized to revolve at 1200 revolutions per minute in order to read correctly in the high-speed photography.

With its work on *Batman Forever* and *Broken Arrow*, The Chandler Group continues to operate and expand as a full-service visual effects house. “We’ve been in the business for fourteen years,” Maples noted, “but there has been a myth perpetuated that we are mainly here to lease out our portable motion control system – and that is not the case. We are strengthening our reputation for doing visual effects photography. Our facility is set up for models. We can design effects, put them together and do the actual photography. There’s a lot that we can bring to the table.”

GORDON SMITH: SEEKING SILICONE SOLUTIONS

article by Christine Sandoval

Twenty years ago, Gordon Smith would never have imagined that one day he would become a premier name in the development of special make-up effects. Now, with his work on HBO's *Truman?* and Oliver Stone's *Nixon*, Smith – along with his FXSMITH crew and some top prosthetics researchers – has made breakthroughs in makeup technology that may forever change the art form.

A classically trained actor who, for a brief time, ran his own theater, the Toronto-born Smith was an unlikely candidate for a career in the often grisly arena of special makeup effects. From childhood, he had suffered from an intense and incapacitating fear of blood. “My father died of leukemia right after I was born,” Smith explained, “and because of that, I developed a very serious blood phobia. It got to a point where I actually passed out at the movies when I saw a shot of a syringe full of blood. That was when I realized that I had to confront this. It was out of control.”

Ironically, it was shortly after the fainting incident that Smith was offered a job on Richard Pearce's Canadian-made *Threshold*. The 1981 movie – about the ethical issues involved in the use of artificial hearts – featured five open-heart surgeries that the director intended to present with a high level of realism. A number of artificial, yet anatomically accurate chest cavities were needed for the surgery sequences; but since Toronto, at the time, did not have a booming effects industry, there were few, if any, local artisans capable of providing such fabrications.

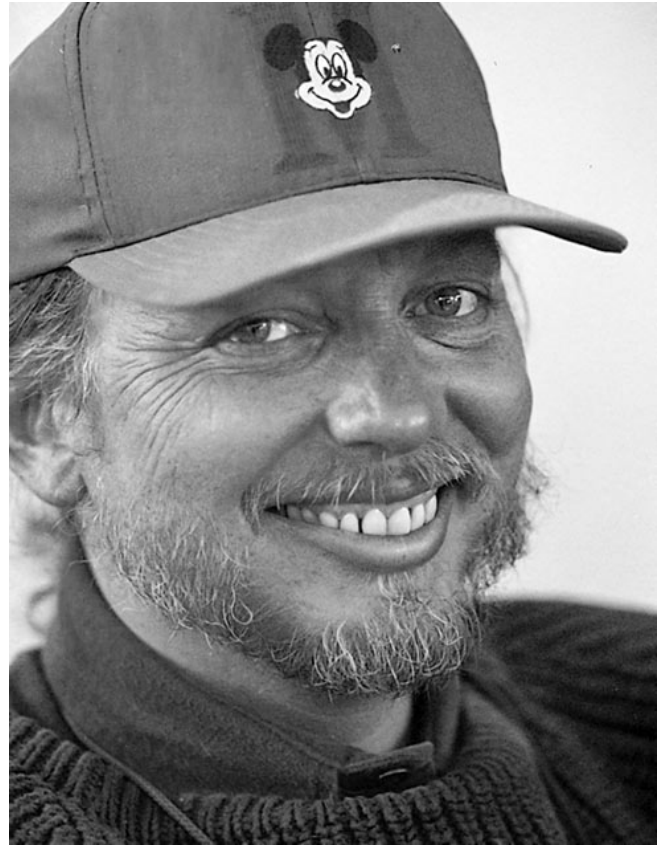
Eventually, Gordon Smith's name came up – primarily because the resourceful actor-director had become known as someone with a talent for building ingenious props. “I laughed when the production company called me,” Smith recalled. “I said, ‘You have *definitely* got the wrong guy.’ But they gave me the job anyway.”

Even as Smith accepted the assignment of realizing the surgery sequences, he was unsure as to how – or even if – it could be done. “One of the options was to film research calves that were undergoing cardiac surgery, which is something that goes on every day. We contacted one of the top cardiac research units at the University of Toronto – so we had that as a backup if it turned out there was no other way to do these sequences. Nobody wanted to do that, of course; but I had serious doubts about whether it was even possible to do these scenes artificially.”

Despite those doubts, Smith – working out of his living room with a small crew, and with the help of top medical consultants – managed to build a variety of devices on which accurate recreations of heart surgery could be performed. The resulting surgery scenes were extraordinarily authentic looking. “I actually got in an argument with a lady in the theater when the film came out,” Smith recalled, “because she refused to believe we had done anything in the movie. Audiences just bought it – they never thought about whether or not there were special effects used in this film.” As a result of his work on *Threshold*, Smith began garnering attention, both within the industry and from the mainstream press. “A Toronto newspaper did a two-page story on us – I’d opened a whole theater and never received that much recognition! So I decided to run with this. We opened a shop and set up for business, calling ourselves ‘The Gore Boys.’”

In addition to providing him with an unusual entry into the film business, *Threshold* and its subject matter enabled Smith to confront his blood phobia, and ultimately overcome it. “You never lose a phobia altogether, but I learned to control it by putting myself in the worst-case scenario with this movie.”

From *Threshold*, Smith went on to work on a series of B-grade horror movies. Dissatisfied with the quality of the films and the unrelenting gore of his own work, Smith was preparing to leave the effects business when he was invited to join Oliver Stone’s production of *Salvador*. “There were all these scenes requiring makeup effects, but they didn’t have much money. The production designer, who was a friend of mine, called me because I was the only person he could think of who would do it for almost no money. I thought *Salvador* was the best script I’d ever read. It was a chance to work on something of quality, for a change; so I was happy to do it. We did all the battle sequences and the big burial sequence – all kinds of stuff.” The collaboration with Stone – which would continue with *Platoon*, *Born on the Fourth of July*, *JFK*, *Natural Born Killers* and, most recently, *Nixon* – was challenging and satisfying enough to keep Smith in the business. Bigger and better jobs continued to come his way, and ‘The Gore Boys’ eventually evolved into FXSMITH.



Makeup artist Gordon Smith is at the forefront of the movement to advance the use of translucent silicone gel appliances.

After a meeting with Dick Smith in 1993, Gordon Smith's career took another change of course. "Dick saw my portfolio and went crazy. He told me I should be developing new prosthetics, because I had probably done more research into translucent materials than anyone in the business. I was reluctant to move into that tight little world, though. I told Dick, 'There is no way they're going to allow me in.' And he said, 'If you have new prosthetics, they will.'"



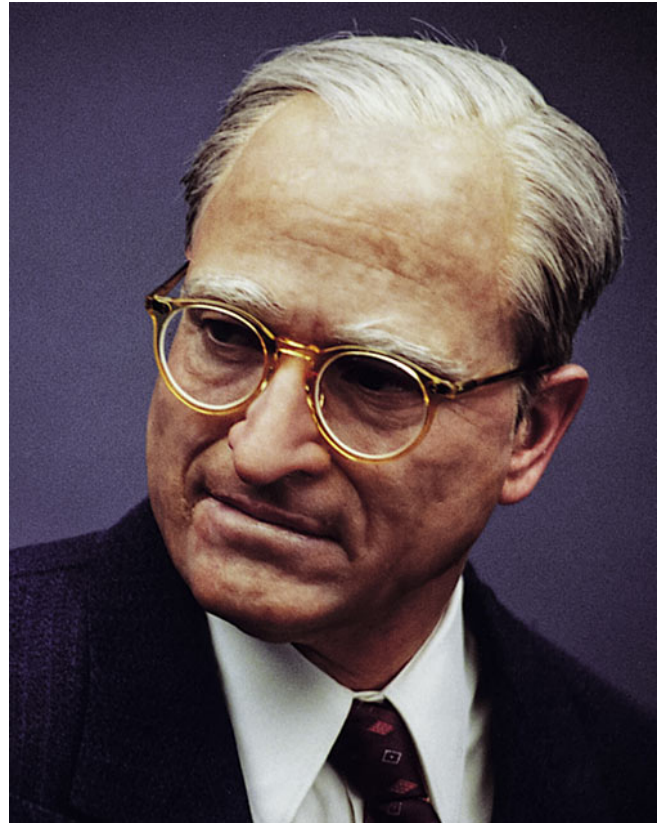
Gordon Tootoosis, aged seventy years, as One Stab in Legends of the Fall.

Motivated by the makeup veteran's encouragement, Smith began working to develop silicone prosthetics that were far superior to foam latex appliances. "We had already developed a polyvinyl siloxane silicone – Safe Cast – for casting and general mold-making. So we were well set up for continuing our research into finding a silicone we could use on an actor as a prosthetic. Procedures were in place for achieving tissue translucency with clear medical grade urethanes; and switching to silicone would only prove easier and safer."

Dedicated to this new goal, Smith contacted Ray Evenhouse, a top researcher in medical prosthetics, to determine the current state of the art in prosthetics technology. "We quickly realized that the procedural difficulties imposed by the medical industry could be overcome by narrowing our focus to the specific needs of the entertainment industry. We knew that if the prosthetic was too difficult to build, it would never fly." With Lorne Barrie – who, while working for FXSMITH had formed Barrie Technologies for the merchandising of Safe Cast and the continuing research of polyvinyl siloxane – Smith, key sculptors Penny and Tom Czarnopy and key technician Ray Mackintosh began testing materials, finally arriving at a clear silicone gel they named Safe Skin.

Smith's patented technique for building silicone prosthetics is similar to that used for foam latex appliances. Safe Cast – or a newer product, Ply-O-Life from Pink House Studios – is used to cast the actor's face, much like alginate. Silicone possesses many advantages over alginate, however. "Alginate shrinks," Smith explained. "It's heavy; and you have to make a plaster master out of it right away. With the silicone, there is no shrinkage, I get a hundred times better detail, and I end up with a second-generation master of the actor's face in mold form."

From the lifecast, a plaster core is pulled for sculpting the prosthetic. Safe Cast and Ultracal molds are made from the sculpture, then coated with a thin, clear urethane – or any material compatible with the silicone gel. The molds are



Gary Sinise transformed into Harry S. Truman for Truman.



Mary Steenburgen as Hannah Nixon in Nixon.

closed, then injected with Safe Skin, precolored to match the actor's skin tones. Curing is accomplished in approximately two hours. "The finished product is an almost picture-perfect prosthetic, with edges – if made properly – that will literally disappear into the skin of the actor. Because the edges are clear urethane, natural skin tone will read right through them. Not only is what's on the actor's face translucent, it also looks and feels almost exactly like real tissue. Also, the pore structure of the prosthetic is exactly that of the actor – it is entirely his own." One of the most important properties of the prosthetic is that it does not need to be painted or blended with makeup – it requires only the make up that would be applied to an actor without prosthetics. Too much makeup, in fact, opaques the prosthetic and ruins its lifelike appearance.

Smith's first opportunity to employ his new materials came when he was engaged to work on Ed Zwick's *Legends of the Fall*. In addition to fabricating artificial African game animals and realizing standard makeup effects, Smith campaigned to do old-age makeups on actors Brad Pitt and Gordon Tootoosis – whose characters of Tristan Ludlow and One Stab were both to be featured as very old men. Zwick's inclination was to simply cast elderly actors in the roles; but Smith, anxious to try out his new technology, offered to do the makeups for only the cost of materials.

Unfortunately, a breakdown in communication between the production and FXSMITH nearly cost Smith the job. "The Tristan that we developed from our reading of the script was in his late eighties, an alcoholic and opium addict who spent the last twenty years of his life in the bush. At some point in production, that concept was changed – but they never got around to telling us. The Tristan makeup we came up with was far too rugged looking. The production interpreted that as a sign that we didn't know what we were doing. As a result, they weren't going to let us do the One Stab character, either. I literally had to beg. I told them I would pay for my crew, everything. Finally, they agreed. We made up the 40-year-old Gordon Tootoosis as the 110-year-old One Stab – and they loved it."

The natural-looking and actor-friendly characteristics of the silicone prosthetics proved beneficial in *Truman*, Smith's subsequent assignment, in which actor Gary Sinise was made to resemble our 33rd president. "Gary had never worn a mask before, and he was not looking forward to working in prosthetics. Psychologically, it is difficult to deal with any foreign material over your own skin? – your face doesn't move the way you are accustomed. But with silicone, I can manipulate the density of the prosthetic to make it as firm or as soft as I want. We made the whole prosthetic area around Gary's mouth very soft; and after a couple of hours of intense work, he learned how to use his facial muscles and how to play the prosthetic."

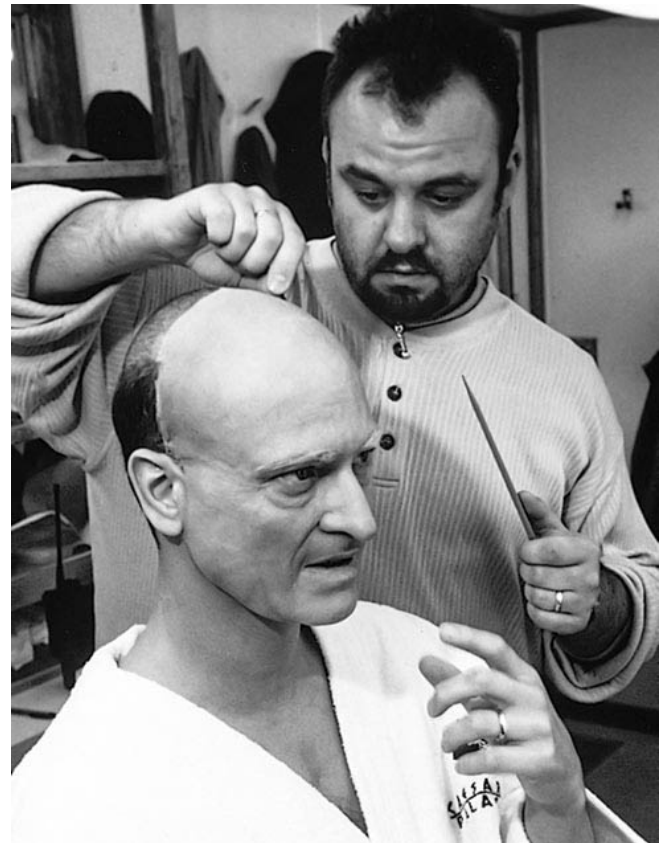
Sinise, as the young *Truman*, had a prosthetic nose, a wig and dental plumpers to give him the distinctive Harry Truman jowls. For *Truman*'s later years, the actor was fitted with a full prosthetic makeup that included forehead, nose, cheek and chin pieces, as well as an upper lip. "If I had to do it over again," Smith admitted, "I would do it quite differently. Multiple pieces were invented by Dick Smith because they were easier to make and apply in foam. But I have found that with the silicone prosthetics, it is much easier to deal with one full piece. When you use multiple pieces, seams have to be put down meticulously; and that takes a lot of time. Making a full piece is more difficult; but because of the ease of application and the flexibility of the material, a full piece creates a much more complete illusion." Actress Diana Scarwid was also made up with a full set of silicone prosthetics for her scenes as the aged Bess Truman.

Despite the fact that *Truman* was heralded for its impressive makeup work, Smith himself was not entirely satisfied with the final results. On the set of *Nixon* at the time, Smith delegated the *Truman* applications to crew members Russell Cate and Ben Robin. When the prosthetics arrived on set, their color failed to match Sinise's skin tone. As a result, makeup had to be applied over them. "Because the technology was so new, Russell and Ben made the assumption that the color match was as good as it was going to get. But that color could have been adjusted in the lab, and the match would have been perfect. As it was, they had to put too much makeup on it to shift its tone – so, visually, it was not that much different than if we had made the prosthetics in foam.

"What I learned from that experience is that we don't build the prosthetics in Toronto unless the film is being shot in Toronto. It is better to actually build the prosthetic right there, with the actor, on the set. That way, we can manipulate the color to match his skin tone, even if that skin tone changes. If we are going from winter into summer and we have an actor who suddenly has a tan, we can build that color shift in the prosthetic, without having to impose it with makeup."

Nixon would prove to be as much a learning experience as *Truman*. Its key makeup challenge was the transformation of actor Anthony Hopkins into Richard Nixon. "I told Anthony, 'We can do this with teeth, eyebrows, a wig, plumpers and lenses,'" Smith recalled. "'You're Anthony Hopkins and you could make that work. Or, we can try and *make* you Richard Nixon.' We all thought it was worth trying. Oliver liked the idea of Nixon being performed in a mask, like a Greek tragedy." Unfortunately, the full prosthetic was not entirely successful. "Anthony was only the third actor we had ever attempted to transform prosthetically. There were still too many bugs to work out."

Part of the difficulty in selling the physical transformation was that *Nixon* would feature many closeups of the actor. "The whole key to the Nixon character is in those dark eyes; so we knew Oliver would be shooting him really close. If we couldn't accommodate those closeups, we'd be better off doing nothing. Any little seam line would have blown the whole thing. The production spent some money and we spent some time trying to do this; but ultimately, we decided just to go with teeth, eyebrows, wigs, and dark brown contact lenses, with John Blake doing the actual makeup. The wardrobe department also had special shoes with two-inch lifts made for Anthony, which threw his center of balance forward, creating the Nixon posture. It was very effective. In the end, I was glad we didn't use prosthetics."



Makeup artist Ben Robin applies silicone gel prosthetics to Gary Sinise during *Truman*.

More complete makeups were designed and executed for the characters of Henry Kissinger and J. Edgar Hoover – played by Paul Sorvino and Bob Hoskins – and for Nixon’s mother, Hannah. “For that, Mary Steenburgen had to be aged to eighty-three. She was in full prosthetics, and we barely had to touch them with makeup. I think that was the best work we’ve ever done.”

Having completed their most recent assignments, Smith and colleagues are already in the process of expanding and improving their silicone prosthetics technology. “We believe that it may be possible to develop a prosthetic that could be used more than once,” Smith related. “The cost of doing prosthetic makeups will be cut down radically – because the biggest cost comes from having to manufacture the same piece over and over again. If we can accomplish that, we will have totally and utterly transformed the prosthetics industry.”

MONEY TRAIN: TRAINING FILM

article by Jody Duncan

At the time Joseph Ruben went into production with *Money Train* – the fast-paced Columbia Pictures release starring Wesley Snipes and Woody Harrelson – the director was determined to produce a film that was virtually effects free. His 1984 experience on *Dreamscape* had left him less than enamored with the visual effects process, and he was reluctant to resubject himself to its inherent frustrations. Even though *Money Train* – the story of foster brothers embroiled in the robbery of an armored train – was packed with images well suited to bluescreen and miniature photography, Ruben's game plan was to achieve all of those images practically.

After several weeks of first unit photography within New York's subway system, the production moved to Los Angeles, where special effects supervisor Phil Corey orchestrated daring, large-scale gags on a subway station set designed by Bill Groom. Comprising three thousand feet of track, the set was the longest in film history. Here, the train derailment and crash that take place near film's end were to be executed in full scale.

Late in production, however, that strategy was revised. Overwhelmed by the logistics of creating a spectacular train wreck live on set, Ruben bowed to the inevitable and delegated a series of key shots to Sony Pictures Imageworks, under the supervision of Tim McGovern. "They had held out hope to the end that they might be able to shoot the train derailment for real," McGovern commented, "but eventually they realized that to do this sequence in full-scale would have been very dangerous. They also wouldn't have been able to create as much havoc as they wanted. There is only so much you can do practically. For those reasons, they decided to do it in miniature – and that's where we came in. What Joe Ruben stressed to us was that, up to this point in the movie, everything had been done for real. He didn't want to suddenly cut to something that looked like an effect. Even though we had only a small part of the show, it was very important that it be flawless."

To ensure that their effects shots would cut in seamlessly with the production footage, McGovern, effects producer Mickey McGovern – no relation – and visual effects director of photography David Drzewiecki reviewed dailies, taking note of the lighting and camera movement styles reflected in the first unit photography. The effects team then choreographed the thirty-second-long sequence in the computer, ultimately producing detailed animatics. "We wanted something more concrete than just storyboards to use in exploring what we might do with this sequence," Tim McGovern related. "We spent three to four weeks doing the computer equivalent of crawling through a tunnel

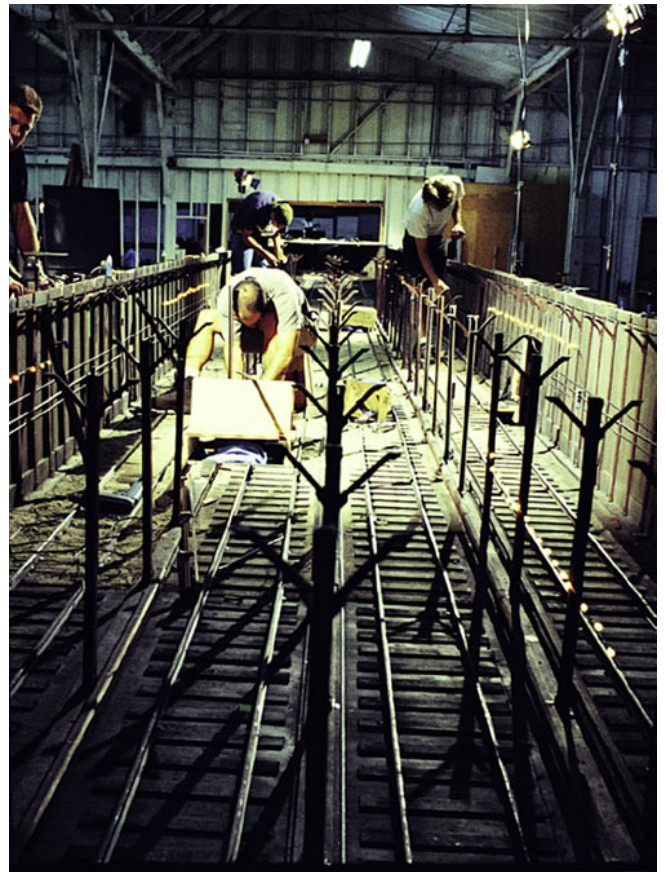


For the action finale of *Money Train*, an armored train derails and crashes into a subway station. Sony Pictures Imageworks produced the thirty-second miniature sequence.

with a viewfinder. Through the animatics, we were able to determine the angles and the action that would make this sequence fit in with the rest of the movie.”

Once animatics were approved, SPI engaged Sessums Engineering to construct the trains that would be used in the miniature shoot. Sessums had provided similar models for Sony Imageworks’ high-profile work on *Speed*; and the company was the obvious choice for the current project. “*Money Train* presented many of the same problems we had faced on *Speed*,” Mickey McGovern noted, “and so we brought in essentially the same crew. We were able to take much of what we had learned on that movie and apply it to this one.”

Sessums constructed two eighth-scale trains, six and a half feet long. Made mostly of aluminum and plywood, the miniatures were equipped with a formidable internal bracing system that rendered them nearly as invincible as the fictitious armored train they represented. “Jack Sessums designed and built the trains so that when they ran into something in the set, they wouldn’t flex or buckle at all,” Tim McGovern said. “Structurally, they were very sound.” With batteries installed, the models weighed in at 143 pounds each.



An eighth-scale subway set was constructed by Scenography and photographed in a large warehouse. Crew members dress the tunnel and ready the cameras – hidden beneath the set for convincing low-angles – prior to fitting the ceiling piece into place. Angled mirrors reflect the action down to the cameras.

Lighting on the models was engineered by miniature lighting specialist Alan McFarlane. "Alan is a real wiz at this stuff," asserted Drzewiecki. "He was able to locate all of these properly scaled fluorescent lamps that were integrated into the train. He also built eighth-scale rotating beacons and other kinds of hazard lights."

While self-contained batteries powered the lighting on the models, propulsion was provided by a motion control rig devised by mechanical engineer Barry Walton and machine shop member Chris Barker. "They came up with a closed-loop cable system that was driven by a five-and-a-half-horsepower servo motor," said Drzewiecki. "The train was pulled along by a recirculating cable that was attached to the back and front. That allowed control over its movement down the track. We could start it and stop it very easily – and because it was motion control, we were able to control the speed of the train precisely. For it to look as if the train was going forty miles per hour in full scale, our model had to travel about twenty-three feet per second, or sixteen miles per hour. That's moving really fast – and motion control was the best way to regulate that kind of speed."

In addition to the miniature trains, the shoot required a like-scaled representation of the subway set erected in Los Angeles. Construction of the replica was subcontracted to Scenography, a local set building company, where it was fabricated in separate pieces. The completed miniature was assembled in a warehouse large enough to accommodate the high-speed shoot. "We had to calculate how much room we would need to do this, based on parameters established in the background photography," explained Drzewiecki. "For example, the train was traveling forty miles per hour in the live-action. From that, we determined what the camera speed needed to be and how fast the model had to move to scale it correctly. That came down to about four inches per frame and a camera speed of 68 frames per second. So if we needed a six-second background plate, we knew that we had to have a set that was a certain number of feet long. We went looking for a sound stage or



Effects director of photography David Drzewiecki checks camera alignment.



One of the train cars - constructed by Sessums Engineering - is rigged to tumble by modelmakers Bob Kredel and Jack Sessums.

warehouse big enough to do this. The warehouse we found had everything we needed – plenty of room and plenty of power.”

Assembled, the miniature set had 120 feet of track and an 80-foot-long tunnel. Although the tunnel was an ample length for filming purposes, its three-foot height and six-foot width provided barely enough room for the film crew’s maneuvering. “When the lid was on the tunnel set,” stated Drzewiecki, “there was no way to get in there except to lie down on skateboards and roll in. It was really confining. Half of my crew members were physically too large to fit into the tunnel – which was just wide enough for the model train to roll through.”

To facilitate low-angles, the set was erected on steel platforms, with cameras positioned below. “The point was to keep the cameras at human height or lower,” said Tim McGovern, “so the train would always look like this big, powerful, unstoppable thing. If you were a witness to this kind of event in reality, this is where you would probably put your camera. We essentially buried the cameras beneath the tunnel set.” Rather than filming the miniature action directly, the cameras were aimed toward mirrors positioned at key points in the set. “Because the cameras were real-size and the train was a miniature, the only way to achieve the effect of the train rolling over the camera was to put the cameras under the floor of the set and point them up into mirrors at forty-five-degree angles.”

The train crash sequence begins with a shot of *Snipes* and Harrelson jumping from the runaway money train as it gains on a passenger train ahead. The characters are seen landing on the roof of the passenger train, then crawling towards camera. While some shots in the sequence were achieved with stuntmen on the full set, others required bluescreen photography of *Snipes* and Harrelson that would be composited with live-action background plates. For the bluescreen work, SPI dusted off its *Blue Max*, a large-scale front projection system devised by Apogee in the early 1980s. “On *Money Train*, we were faced with a classic blue screen problem,” observed Drzewiecki. “The camera was to be placed at an oblique angle on the roof of a train as our heroes crawled along it. The surface had a brushed stainless steel finish that would have reflected the blue, causing holes in the matte and color correction problems. Not only that, there was Woody Harrelson’s blond hair blowing around, which would have been very difficult to matte successfully. The *Blue Max* – being a front projection system – solved all of those problems, eliminating any spill or bluescreen contamination on the roof of the train or in Woody’s hair.”

To prevent the money train from impacting with the passenger train, the foster brothers devise a way to throw its controls into reverse, resulting in its sudden derailment and subsequent crash. “The first thing the train does is go off the track,” stated Tim McGovern. “You see it cut across all four lanes of track, taking out columns and sparking as it goes. Then the train moves across the tracks on a diagonal, finally hitting the far wall, which is a huge junction-box kind of setup. The train begins to roll and tumble, doing four full revolutions before it stops – and it had to stop exactly in the right position in order to match up with the full-scale train shot earlier.”

The initial derailment, shot as a Vistavision background plate, was achieved by running the train on a hidden rail that moved it away from the main line. A second, more complicated setup was required for the following shot of the train beginning its roll. “A carriage was built to keep the train tilted as it ran down the side track,” McGovern said. “There was cable wrapped around the train a

number of times. When that cable was pulled, it caused the train to roll, unreeling like a spool of thread. The train then started its diagonal move, taking out columns in the set.”

All of the necessary cables were hidden within the miniature so that digital wire removal would not be required after the fact. “We did wire removal the old-fashioned way,” Drzewiecki quipped. “We just didn’t photograph them in the first place.”

Excitement was added to the shots with pyrotechnics masterminded by Ian O’Connor and Neil Smith, who rigged the set so that as the train ran through it, the model would hit a number of preset pyro charges. “There were tripwires and microswitches for everything,” said Tim McGovern. “In a sense, the whole set was a kind of nailboard, with the model train hitting its marks and setting off pyrotechnics accordingly.”

Pyrotechnics also provided illumination for the action. “The established look of the movie was quite dark,” Drzewiecki noted. “Obviously, there isn’t a whole lot of lighting in a real subway tunnel. Most of the illumination on the train and the people and the tunnel came from incidental light sources – hazard lights on the wall, for example, or electrical sparks.” During the full-scale shoot, carbon arc units had been rigged to provide those electrical sparks. “It was outside of frame, but it helped to create this sparking, frenetic lighting. We had to simulate that in our miniature work, as well, which we did with flashbulbs placed throughout the route of the train. As the train traveled, those flashbulbs were going off all over to create a frenetic lighting pattern.”

After the train completes its four revolutions, it continues to slide down the tunnel, finally coming to a rest in front of camera, surrounded by debris. The train at rest had been filmed by the first unit crew, and that full-scale shot had to be matched in the miniature photography. “It turned out to be a simple thing to do,” stated Drzewiecki, “because of the magic of motion control. The train stopped on a dime, and in exactly the right way.”

Remarkably, after ten days of being derailed, rolled and crashed into set pieces, the sturdy train model was still in good condition. “Even the miniature fluorescent lights didn’t break,” McGovern marveled. “Fortunately, the full-scale train we had to match hadn’t been beaten up too badly, either. There was a big yellow beacon light hanging down the side of it that had survived the live-action shoot and was still blinking. We were worried about that, because we thought our beacon light would be smashed to bits during the course of the miniature shoot. But, sure enough, it never broke.” The whole model held up so well, in fact, that the backup provided by Sessums was never employed.

After the shoot – which yielded thousands of feet of film – Joe Ruben came to SPI to cut the sequence together. The director, who had resisted the effects solution to his film’s climax, was more than satisfied. “Joe is not an effects-driven director at all,” Tim McGovern commented. “He really just likes to shoot things right there, in-camera. But when he saw how well our shots cut in with the rest of the movie, I think he realized that doing the sequence in miniature was the best approach.”

BABE: FROM THE MOUTH OF BABE

article by Estelle Shay

When television audiences tuned in to the amiable banter of *Mr. Ed*, they accepted the fact that the talking animal effect was unconvincing, even downright corny. This was, after all, television; and, a horse is a horse. A higher standard was met when Available Light employed refined cel animation techniques to create the illusion of speech for some of Willow's conversational critters. Cutting-edge computer animation was later utilized by Rhythm & Hues for *Hocus Pocus*' loquacious cat. But never has the effort to endow animals with the ability to speak been as successful as in *Babe*, a Universal Pictures release of a Kennedy Miller Production, directed by Chris Noonan.

Babe, a charming comic fable based on a children's book by Dick King-Smith, tells the story of a good-hearted pig who dares to be different. Arriving at Hoggett Farm as a piglet just separated from his mother, *Babe* takes solace in the maternal ministering of Fly, a female sheep dog, and from her learns the ways of the barnyard. After rescuing the resident sheep from poachers, *Babe* aspires to sheep dog status – arousing the ire of Fly's mate, Rex, and upsetting the delicate social balance of the farm. In the end, the brave, gentle porker wins the day, earning the respect and admiration of both animals and humans.

With talking animals accounting for nearly eighty percent of its dialogue, *Babe* would require sophisticated visual effects – both animatronic and computer generated – in combination with live animal performances. “When they first came to me, in 1992, and said they wanted to do this project with hundreds of CG and animatronic shots, I was skeptical,” recalled visual effects supervisor Scott Anderson. Despite his reservations, Anderson was impressed with the amount of preparation and planning that had already gone into the project; and, in 1993, he joined Noonan, postproduction supervisor Marcus D'Arcy and animal trainer Karl Miller for a lengthy strategy session in Australia. “We went through the whole film, breaking it down by storyboards to see how each shot could be accomplished. From a budgetary standpoint, we knew we could only do about a hundred CG shots – but we needed three hundred shots to tell the story. Our original thought was that CG would be used for transition shots – when there was a real animal in the middle, we'd do CG on either end – because we knew that matching the look of an animatronic to a particular animal would be difficult. But as filming went on, that approach changed. Some shots were obvious – if an animal was walking and talking, it had to be CG. Others worked better as an animatronic. Ultimately, we ended up with about 150 animatronic shots and 130 CG shots – pretty much what we had budgeted for, but not the exact shots we had predicted going in.”

For shots requiring an animatronic solution, Noonan and Anderson turned to Jim Henson's Creature Shop in London. There, a crew of forty, headed by Neal Scanlan, tackled the difficult task of building articulated animal clones that could be interchanged convincingly with their live counterparts. "It was a huge job," noted Anderson. "Every animal with dialogue required an animatronic double – eleven different creatures in all – with key characters such as Fly and Babe demanding multiple builds to accommodate varying poses." Supplementing the Henson puppets were six animatronic sheep built by two Australian companies – John Cox's Creature Workshop, responsible for sculpture and cosmetics, and Robotechnology, which built the internal mechanics designed to hook up with the Henson performance stations used on location.

Even with Henson expertise at their disposal, the filmmakers knew that not all of their talking animal shots could be realized with animatronics. To fill the gap, the producers turned to Rhythm & Hues, where live-action animal performances were blended seamlessly with 3-D computer graphics animation. "We wanted the speaking movements of the animals to be so anatomically believable," said company visual effects supervisor Charles Gibson, "that audiences wouldn't think they were simply seeing a pig that happened to be moving its mouth in cadence to the dialogue."



Computer graphics from Rhythm & Hues turned live animals into talking characters in Babe.

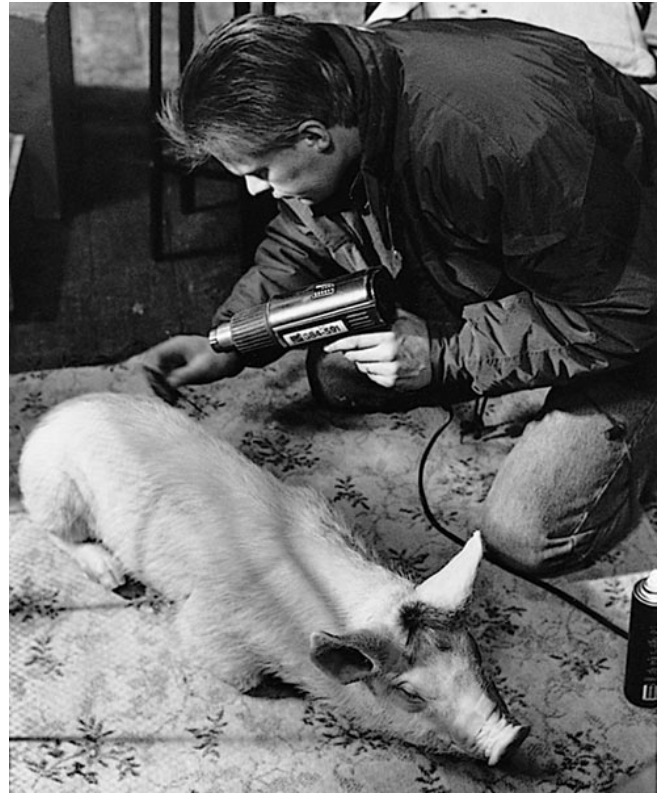


Computer graphics from Rhythm & Hues turned live animals into talking characters in Babe.

The technique employed by Rhythm & Hues entailed tracking the live-action performance in the computer, then grabbing the appropriate image and incorporating it into a 3-D computer model of the head. The model would then be modified as needed – even partially synthesized for portions of the face that were nonexistent in the original photography. “Our basic philosophy was: ‘Nothing looks as real as the real thing,’” Gibson stated. “Our goal was to replace only the parts of the face that needed replacing, leaving as much of the real animal as possible undisturbed.”

With Noonan set to film the entire movie on location in Australia, Gibson and Rhythm & Hues producer Liz Ralston flew there for the start of principal photography to pin down creative and technical issues, and to gather a master database of reference photos on the animals. After their return, further communications between the Los Angeles-based company and the production were arranged through an Internet link established at the two locations. “We spent two or three months after filming began doing test animation and lighting on each of the characters to perfect our technique,” recalled Ralston. “Since the entire picture was cut on the Avid, we developed software so that we could send our animation tests over the Internet, formatted to cut directly into the Avid. That way, the production could see how it looked and give us immediate feedback – which was a godsend. I don’t know if the picture could have been done any other way.”

On location, a small army was assembled for the nineteen-week shoot, including more than five hundred animals and a crew of two hundred that included a fully staffed creature shop to handle the animatronics and a sixty-person animal training contingent. “Working with the Henson puppeteers, we were able to experiment with the animatronics during the shoot,” commented Anderson. “Before we even got into doing the CG, we could play with mouth shapes and actions and camera angles,



Animatronic animals were created by Jim Henson’s Creature Shop. Supervisor Neal Scanlan dries off a puppet Babe after a rainstorm scene.



Anton Boniface tests an animatronic Fly.

looking at video tests and dailies to see what worked and what didn't."

Concurrent with the testing underway on location, Rhythm & Hues modeling manager Keith Hunter and modelers Nancy Klimley, Tex Kadonaga and Doug Ikeler began construction of the wire-frame head geometries that would serve as the basis for animating the characters' faces. Since it was impossible to take lifecasts of the live animals, modelers based their computer heads on castings provided by the Henson team, and on custom sculptures by Cox's Creature Workshop.

As the production began transmitting footage to Rhythm & Hues, the digital team tackled the arduous task of tracking their computer models to the live-action using specially designed software and three-dimensional rotoscoping techniques. "We would do a lock-down from the eyes to the nose – the most solid points we could find on the face," noted Liz Kupinski, who supervised the CG work along with Todd Shifflett, Eileen Jenson and Harold Buchman. Discrepancies between the computer model and the real animal made the tracking process especially time consuming.

"Dozens of animals were used over the course of filming to portray one character – each animal possessing slightly different characteristics – so our models didn't always match precisely from one shot to the next. For that reason, we were continually having to go back and make adjustments."

Frequently, parts of an animal's face – such as eyes, tongue, teeth or interior of mouth – would have to be created from scratch. "That was often the case when we were animating the sheep dogs," remarked Kupinski. "The dogs' mouths would be hanging open in the live-action footage, and we would have to put in fake jaws to make it look as if they were talking."

Synthesized parts were occasionally subject to artistic license. "We tried to avoid the tendency to make everything appear too perfect," Gibson elaborated, "by creating an organic, asymmetrical look. For the mouth interiors of the dogs and the pig, we went with a less detailed interpretation. A dog's mouth has a lot of saliva, ridges, freckles and coloration in it; but that was not visually compatible with the rapid movements of the mouth opening and closing in speech. So we cleaned it up somewhat – reducing the tongue bump and the intensity of the teeth to eliminate any flashing or artifacts that might be distracting. We did the same for the pig's mouth, leaving out the folds and creases and simplifying the anatomy."

Once the computer models were tracked to the live-action, lead animators Sylvia Wong and Nancy Kato were tasked with creating believable facial expressions in sync with the dialogue. "Not only were the animation demands different for each animal," noted Gibson, "they were different for each shot. Sometimes we were scrunching up the whole face for a very concerned look, and sometimes it was just a simple blink of an eyelid and a bit of mouth movement. We were never able to create a library of expressions because there were just too many variables. The type of animal, the dialogue, the angle of the shot, the lighting – all of that influenced our decisions about which parts of the face to move, and how."

At the heart of the animation problem was the need for realistic movement within the constraints of jaw structures not designed for speech. To aid the animators, real farm animals were brought in so that mouth structures and anatomies could be studied closely. "We were always dancing on a fine line. If we moved a jaw in a totally realistic fashion, it would look as if the animal was just chewing. But if we were too expressive with the lips, it would look like a rubber mask. In every instance, it was a matter of finding a level that worked for that moment in the movie. What worked

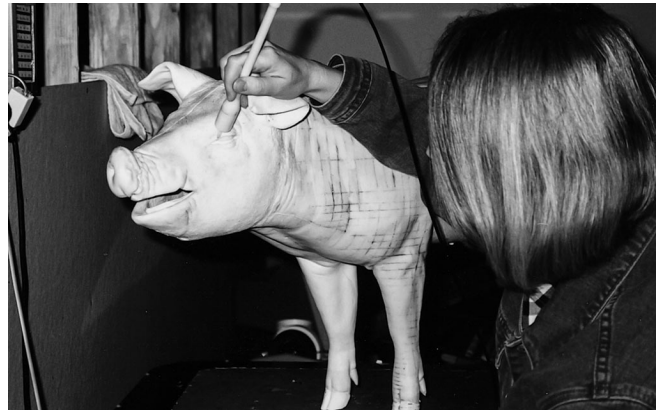
for one animal didn't necessarily work for another. It really had to be determined on a case-by-case basis."

As the animators became more comfortable with the process, they reevaluated their approach and applied some midcourse corrections. "We found that we were pulling off the realism part, and moving the animals' mouths and faces well," recalled Gibson, "but that we were being a little too conservative. So we began pushing the performances further – with snappier animation and more exaggerated movements."

Among the most difficult shots were those involving the sheep dogs, Fly and Rex – especially in instances where it became necessary to replace their eyes. "We tried not to do that for the most part," remarked Gibson, "but there were about ten shots – where the dogs were squinting or looking in the wrong direction – when it was unavoidable. The eyes were difficult to duplicate because they were so full of expression and intelligence, and so beautifully lit. We would find another dog's eye in our footage that we felt fit the scene, and copy that, making a digital, synthesized version with all the right sorts of glows and internal reflections."

Another difficulty with the dogs was finding a way to realistically render their hair in digital form. While all of the other farm animals were short-haired, the sheep dogs sported long furry coats that made for a complex rendering task. "It was a two-fold problem," Gibson stated. "Not only did we have to create digital fur around the nose and chin of our model, but we also had to match and blend it seamlessly to the existing fur in the live-action shot."

Many shots required background replacement in order to fill in gaps resulting from the animated opening and closing of a character's mouth in profile. "For stationary backgrounds, we could just grab things from another part of the scene," said Kupinski. "But for shots where people were walking behind the character, our painter, John McGee, had to go in and hand paint the background frame by frame. Then we had to match it up with the existing background. Since nothing was shot using motion control, it was very tricky getting everything to line up."



Nancy Klimley of Rhythm & Hues digitizes a casting of Babe to create a wire-frame model.

As rough animation was completed for each shot, Gibson would transmit the images to Noonan on the Internet, where they were cut into the workprint. "It was really important to have that constant interaction with the director," noted Gibson. "He was our barometer of how legible and emotionally communicative our work was."

At the conclusion of principal photography, Anderson returned from Australia and joined with Kennedy Miller effects producer Nancy St. John to act as liaison for the ten-month post production at Rhythm & Hues, during which the shots were finessed into final form. Refinements included lighting, texturing and occasional paint fixes to match the computer animation with the live-action footage. "We had a responsibility not only to make the shots photo-real," Gibson commented, "but

also to create something that was consistent with director of photography Andrew Lesnie's concepts. The film had a very definite look to it; and it was our job to emulate that style."

Babe opened in August, delighting critics and audiences with its unconventional charms. "There was a large leap of faith on the part of everyone involved in making this movie," Scott Anderson observed. "A lot of people didn't believe that the animatronics would work or that the digital effects could be done at that level. It was really gratifying that we were able to do such a technically and creatively intense project – and have it come off on screen looking as if it were easy."

CASINO: THE LIGHTS OF LAS VEGAS

article by Mark Cotta Vaz

After the elegant intrigues of *The Age of Innocence*, director Martin Scorsese returns to the conflicts of mean streets and made men with *Casino*, a Universal release set in the Las Vegas of 1974. Actor Robert De Niro stars as Ace Rothstein, owner of the Tangiers, a fictitious casino dropped into the Vegas Strip amidst the *Dunes*, *Flamingo*, Caesar's Palace and other glittery hotels and casinos of that period.

The challenge for Scorsese, designer Dante Ferretti and other production principals was that the Vegas of old had been completely replaced by the edifices of a new entertainment order. Today, Las Vegas is a fusion of theme park spectacle, family-friendly diversions and ostentatious structures such as the MGM Grand, which has been proclaimed the world's largest hotel.

"The Vegas of 1974 is as dead as ancient Rome," noted digital matte artist Chris Evans of Matte World Digital, the Marin County effects house called in by Scorsese to recreate the Strip. "At that time, the Strip had the Tropicana and the *Flamingo* hotels, as well as the 180-foot-tall *Dunes* sign, which was the tallest structure on the street. Those have all been torn down; and now these new, enormous hotels fill the sky in all directions. Since Scorsese wanted to put the Tangiers in the Strip of 1974, we couldn't just shoot a plate on location and add a sign. We had to start from scratch."

Charged with only a small slate of shots, Matte World Digital was able to concentrate its high-end creative and technical resources to recreate the classic Las Vegas Strip. In addition to newly developed rendering and paint programs, the company utilized Kodak's Cineon Digital Film System – a high-resolution file format – for their work on *Casino*. "We specialize in the creation of environments," said Craig Barron, owner of Matte World Digital, "and we're very critical about having our shots cut in perfectly with production footage. Our advantage as a digital matte painting company is that we don't do high-end animation effects, such as morphing or creating CG characters. Since we're not working on three hundred shots that require a compressed file format to meet a deadline, we can take time and finesse our shots, working in a high-resolution format like Cineon."

The format proved advantageous in several establishing shots of a secret mob hangout at a gas station – shots the company might once have produced as latent image matte effects. The use of the Cineon format provided the dual advantages of a high-resolution composite of live-action photography and a traditionally painted image, as well as the creative freedoms of the digital realm. "We still have a nostalgic regard for the latent image technique – which, because it was on the original negative, had no image degradation," Barron observed. "But now we can scan our footage into the Cineon format, which captures images at 10 bits per pixel, 100 megabytes per frame. That's a dynamic range that has no image degradation when cut into the original photography."

In addition to live-action gas station footage, the hangout shots featured four-by-five-foot glass paintings – rendered by Chris Evans – that provided a background of city buildings, signs and an elevated train trestle. Paintings of clouds were placed on a mover and photographed separately by

effects cameraman Cameron Noble. “We then produced precomposites that consisted of the city and sky paintings, with live-action steam and smoke stack elements,” Evans explained. “Then our digital compositor, Paul Rivera, combined that precomp with the live-action plate using Wavefront Composer. Because the compositing was done digitally, we were able to tweak the image and get the color balances just right.”

Digital technology also provided the means for producing CGI versions of the famed, onion-shaped Dunes sign – torn down in 1993 – as well as a lighted sign in front of the fictitious Tangiers Hotel. Specifically, Matte World Digital was able to take advantage of its test-site status with Light scape, a Silicon Valley firm that had developed a breakthrough radiosity rendering system.

Radiosity software was developed originally in the early 1960s by thermal engineers to simulate the transfer of heat between furnace and engine surfaces. In the mid-1980s, computer graphics researchers at Cornell University investigated the applicability of the technique for simulating light propagation in architectural models. By 1993, a group of Cornell graduates had founded Light scape and positioned radiosity in the marketplace as an architectural rendering software.

Barron’s interest in creating realistic looking CG environments with radiosity inevitably led him to Lightscape. In fact, Barron had been tracking the development of radiosity software since 1984, when, as director of matte photography at ILM, he had picked up an issue of *Scientific American* illustrated with examples of the nascent rendering system. “Radiosity was no more than a doctoral thesis when Craig saw the applicability for film,” commented Rivera. “Craig showed me the original *Scientific American* article with these pictures of a computer graphic room with scattered shafts of light; and it looked so real. Even though the CG was crude, the lighting provided a high degree of realism that had not existed in a CG image before.” By the time the *Casino* project came along, Barron had already been working with Lightscape vice president Stuart Feldman on the creation of tools to apply radiosity to film effects work.

Before the advent of radiosity, the rendering of a 3-D model for film had been achieved with ray tracing, an algorithm useful for calculating direct illumination, as well as capturing such reflective surfaces as chrome or mirrors. The limitation of ray tracing was that it only accounted for the light arriving from a specific source, ignoring the indirect lighting sources and ambient gradations of light at play in the real world. “Since ray tracing does not account for diffuse light and diffuse interreflections of light, images are very contrasty, and CG buildings and landscapes can look flat,” explained digital artist Morgan Trotter. “You have to specifically direct ray tracing to ensure how the light is going to go. But radiosity deals with light as energy; and every time it hits a surface, it diminishes and becomes softer and softer, which is more natural looking. It accounts for diffuse interreflections, which we call bounce light.”

In the radiosity system, the 3-D wire-frame surface of the model is broken down into two-dimensional triangles and rectangles, called ‘the mesh.’ On a monitor, the 2-D mesh can be seen to physically represent all illuminative gradations, from strong source light to softer, more diffuse bounce light. “Envision a traditional wire-frame model,” Barron said. “It is wrapped with what looks like a spider web showing the different levels of the bounce light, with more polygons on it where you need subtler gradations. The mesh is calculating the light distribution and energy on all of the surfaces that exist within the scene. Radiosity is a whole different way to shine light on an object.”



For Casino, to restore Las Vegas to its 1974 appearance and create the fictitious Tangiers Hotel and Casino, Matte World Digital used classic matte painting techniques updated with sophisticated digital embellishments.



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Rendered in radiosity, the *Dunes* sign was composed of 2.5 million mesh elements, and the *Tangiers* sign some 158,000 elements. “Radiosity calculates the energy and the resolution on that mesh surface,” Barron explained, “so before we created our images, we had to determine at what mesh resolution we needed to work to create a realistic looking object. You can change the mesh resolution to determine the subtle gradations of light values on the different surfaces. The higher the resolution of the mesh, the more subtle the gradations of light.”



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One of the advantages of radiosity is that once the mesh has been calculated, the angle on the model can be moved without the model having to be re-rendered. That capability came in handy when, late in the postproduction period, Scorsese requested a new, up-angle shot of the *Tangiers* sign. “When you change the camera view in traditional ray tracing,” observed Barron, “the renderer has to re-render the frame. With radiosity, because the distributed light is already calculated on the mesh, the 3-D object can be rotated and placed at a new angle, without having to be re-rendered. That’s an enormous computational advantage. Morgan could also assign a specific value for each light on the sign, allowing him to create a look where a tube might have gone out or dimmed here and there. We were putting our CG models into an environment next to signs that still exist on the Strip, so our CG signs had to match exactly the look, lighting cycle, contrast and reflectivity of the real signs.”

Exterior views of the *Tangiers Hotel and Casino* featured live-action footage of the *Landmark Hotel*, an off-Strip establishment owned by the reclusive Howard Hughes during Vegas’ glory days and abandoned since the 1960s. For an establishing shot, new buildings were removed from location plate photography and replaced with both the *Dunes* of old and the mythical *Tangiers*, complete with a turban-inspired porte-cochere. The bottom half of the *Landmark*’s existing porte-cochere was lined up with a CG turban model – rendered with both ray tracing and radiosity – that replaced the upper half of the hotel’s entranceway.

Another Vegas view provided by Matte World Digital is featured in a shot of Rothstein relaxing in his private penthouse, gazing out the windows at the glittery Strip. The live-action was staged in a penthouse of the *Riviera Hotel* that afforded a view of the *Landmark Hotel* in the distance. Using the *Landmark* tower as a centerpiece for their background plate, the effects artists created the rest of the nighttime tableau by combining six different Vistavision plates shot from various Vegas rooftops. Topping off the final composite was a view of the computer generated *Dunes* sign.

The penthouse shot required tweaking of all the plate elements to fit into the suite’s window frames. To meet the compositing challenge, Paul Rivera utilized *Liberty-64*, a high-resolution paint compositing package developed by Chyron. Like *Lightscape*, the East Coast-based Chyron had entered into a test-site arrangement with Matte World Digital. “Chyron is interested in providing high-end houses with the tools they need,” noted Rivera. “We started working with them, and they came up with these incredible 10-bit tools. When we first started this project, the painting tools

available were all in 8-bit – we didn't know of *any* in the 10-bit range. But Liberty-64 allowed us to warp buildings and actually do a cut-and-paste in 10-bit."

Once upon a time, Matte World artists utilized the entire playbook of matte painting techniques to create environments, from latent image to combining paintings with models. Now, the digitally recast company can point to a variety of tools – from radiosity to high-resolution film format and painting packages – that represent significant breakthroughs for the future of virtual effects. "To simulate camera movement through traditionally created effects shots required a miniature or 2-D matte painting," Craig Barron observed. "Now, with CG, the goal is to move dimensionally through a 3-D environment combined with live photography. As we evolve into the digital age, we will continue to develop the equivalent of our traditional tools in the computer graphics realm. To do that takes more than just rendering shots. We have to create a whole new set of tools that didn't exist before. The goal is to make CG models undetectable when combined with live-action scenes – and that involves a lot of research and development."

THREE WISHES: MAKING WISHES COME TRUE

article by Estelle Shay

In *Three Wishes*, a Capraesque fantasy set in 1955, a chance encounter with a vagabond and his dog profoundly changes the lives of a mother and her two young sons. When Jeanne Holman (Mary Elizabeth Mastrantonio) accidentally injures drifter Jack McCloud (Patrick Swayze), she invites him into her home to convalesce. That simple act of kindness propels the family on a spiritual journey, invoking magic and miracles along the way.

The movie's mystical overtones are portrayed through the bond that develops between five-year-old Gunny Holman (Seth Mumy) and Jack's dog, Betty Jane. Seen through the child's eyes, Betty Jane is a magical being with the power to summon strange and delightful visions. To depict the surreal elements in an otherwise realistic story, director Martha Coolidge, producer Larry Albucher and visual effects producer Laura Buff turned to animation expert Phil Tippett, whose Berkeley-based studio affirmed its commitment to digital effects with some fifty computer generated shots.

In a series of production meetings, Tippett worked with Coolidge and writers Clifford and Ellen Green to flesh out specific story elements. "There were some pretty significant story problems at first," Tippett recalled. "The entire visual manifestation of the magic was going to be spelled out in three phantasmagorical scenes; but with the exception of the third one, the script was very vague, and there was no expositional device to explain Gunny's visions. The trick was to find some kind of visual hook that we could pull all the way through to the end. We did that by introducing little light creatures that appear in each of the sequences. We kind of backed into that concept, basing it on Gunny's apparent fascination with fireworks – revealed in a later scene."

Another narrative thread was developed for the shadow creature, a frightening but benign being that appears to Gunny in the first fantasy segment. "We were looking for story snippets – nothing to really hit you over the head – that would tie into the illusion and serve as a metaphor for Gunny's fears. We came up with the scenario that Gunny's father, who is missing in action in Korea, has sent back a scary looking artifact – the kind of thing the older brother might use to torment the boy. We started with that as a basis for our designs."

As the scene begins, nighttime shadows play on the wall of Gunny's bedroom and flicker across his face. A wall-mounted lamp shorts out, and the shooting sparks transform into tiny light creatures that attach themselves to the wall, melting it away. Experimenting with different levels of light interactivity, Tippett used Alias software to render the light creatures and Softimage to animate them. A series of animated masks created the illusion of the opening wall. "On top of the animated masks, we



laid various pieces of 2-D artwork to suggest the layers burning away.”

The effect expands with a primordial forest quickly encroaching on the boy’s bedroom, vines slithering up the walls. “For those shots, we used computer generated plants composited with live-action footage of prop plants on the set,” said Tippett. “We matched our CG plants to the props to ensure continuity with the live-action, then animated them growing up to the ceiling.” A shudder ripples through the room foretelling the arrival of the shadow creature, a live, mammoth incarnation of Gunny’s artifact. The creature stomps into view, stopping at the foot of the bed to peer down at the wide-eyed child.

Art director Craig Hayes designed the shadow creature, fashioned first as a wire-frame computer model, then texture-mapped and painted. To animate it, Tippett outfitted mime artist Leonard Pitt with a motion capture device, directing the performance in real time. “We first started playing around with the idea of an input device in *Jurassic Park*,” Tippett recalled. “Craig designed it; and we have continued to refine it, developing a version that works in key-frame mode for stop-motion animation and in real time for motion input. From fifty to eighty percent of the shadow creature’s movements were based on Leonard’s performance. It was the backbone of the animation, and imbued it with the kind of spontaneity that you don’t get by sitting around a computer and clicking a mouse. Once we had that, Blair Clark fine-tuned it, adding all the ancillary animation.”



Gunny is later enveloped in a swarm of tiny light creatures.

The shadow creature extends his giant hand, opening it to release a flurry of tiny light creatures. As a mesmerized Gunny reaches out, the creature pulls back the light. The shadow creature then advances on the child, who ducks under his covers as the giant hand descends to gently stroke him. “The hand animation was also done with motion capture,” noted Tippett, “and later finessed in the computer by Blair Clark to match bedcover movements rigged by physical effects supervisor Dave Kelsey on the live-action set.”



A scene in which the youngster flies over a carnival incorporated live-action greenscreen and a digital stunt double.

In the second sequence, the dog begins to glow, then disappears in a shower of sparks and incandescent shapes that orbit the room, floating and bouncing off each other in a dazzling display. Standing on his bed, Gunny tries unsuccessfully to clasp the glowing objects in his hands as they encircle him. “Martha Coolidge was insistent that the light creatures be playful and fun in this scene,” stated Tippett. “We wanted to stay away from conventional points of light and devise something that was evocative of a child’s world. With that in mind, Craig came up with the idea of using little anomalous forms – like diatoms or building blocks of life. We showed some of our early tests to sound designer Leslie Schatz, whose sound effects – which incorporated children laughing? – helped to drive the animation.”

To move the light creatures through space in their various orbits, animators used a special puppeteering version of their motion capture input device. “We would assign a point in space as a light creature,” Tippett elaborated, “figure out where the various coordinates of the room were, then fly the input device around by hand in real time, using it to create animation paths.”

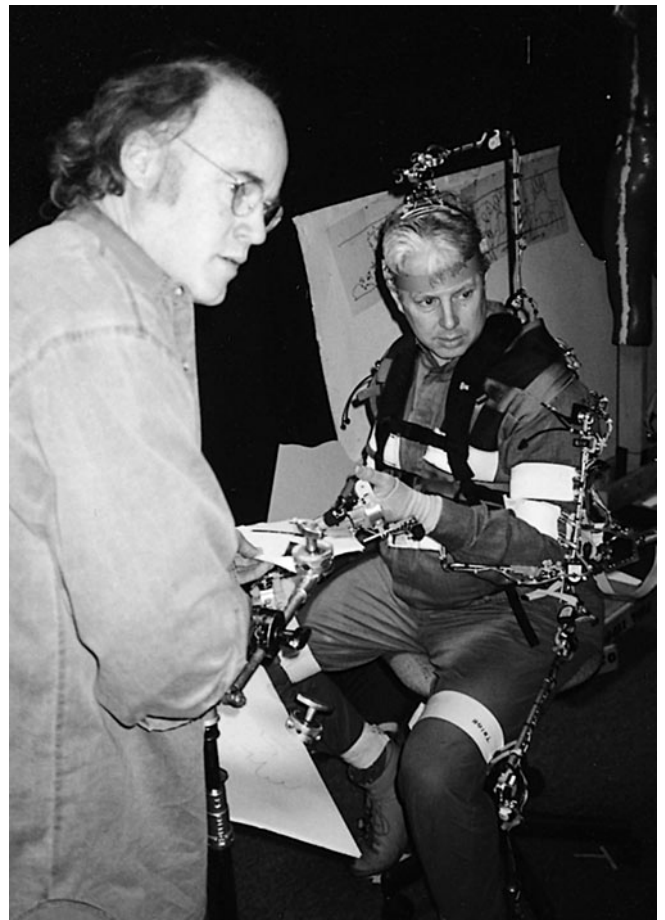
Interactive illumination on the child and the room was accomplished practically during the live-action shoot using a rotating cookie-cutter-type device to break up the light. “Director of photography Johnny Jensen came up with that solution,” recalled Tippett. “We worked closely with him to shoot the background plates, previsualizing the size, color, temperature and speed of the light creatures that we would be laying into the shots during postproduction.”

A key element in selling the sequence was the performance by young Seth Mummy. “Trying to get a five-year-old to respond appropriately to something imaginary was no easy task,” Tippett stated, “especially since we weren’t even sure at that point what the light creatures were going to look like. We tried every trick in the book, from dangling little tchotchkes in front of him to puppeteering things around his head. But those sequences were shot towards the end of the production; and although he was very compliant, Seth’s patience was fast running out. It was a real challenge finding ways to keep him engaged.”

Unlike the first two fantasy scenarios – which unfold in the intimacy of his bedroom – Gunny’s third brush with magic takes place at a July Fourth carnival, where he wanders away from his mother to observe the fireworks from a rooftop vantage point. Stretching his small arms skyward, Gunny delightedly finds himself airborne, soaring high into the night sky amidst the colorful explosions.

He swoops down and follows the dizzying loops of a roller coaster ride, flying just inches above the track, then shoots directly to the center of the pyrotechnic display, traveling through the heart of an exploding burst and dissolving into it.

To visualize the complex twenty-seven-shot segment, Tippett first produced a series of animatics. Filming began with closeup shots of Gunny in flight – accounting for nearly two-thirds of the sequence – that were accomplished with the young actor suspended in a flying rig on a greenscreen stage. “Dave Kelsey designed a special rig for Seth,” explained Tippett, “and Bill Neil was the director of photography for the two-week shoot. We used a locked-off camera most of the time, and shot quite wide – which allowed us to add some movement when we tracked the character into the plates.” For shots involving extensive tracking, or acrobatics that the rig could not accommodate, digital artists built and hand animated a computer generated stunt double of Mummy.



Phil Tippett directs Leonard Pitt during a motion capture session for the shadow creature.

The greenscreen elements were scanned into the computer and composited against background plates that included a full-size amusement park set – constructed on location in Valencia – stock footage of real fireworks and computer generated fireworks. Technical supervisor Julie Newdoll made certain that lighting, atmospheric conditions and perspectives all matched. “Tracking the character to background plates of the amusement park was especially tricky,” Tippetts noted. “Those plates, shot from a helicopter, were very unsteady; so not only did we have to artificially generate Gunny’s movements in the frame, we also had to lock him into a jittery background.”

Having embraced the digital revolution with *Three Wishes*, Tippetts is nonetheless philosophical about its significance. “I’m quasi-enamored with the computer as a tool that can do everything from composite your shots to clean your socks. It’s a tool that has yet to acquire the patina of craft. There are so many hidden anomalies that it’s like some strange mathematician’s platonic vision of how I, as a craftsman, would put things together. Certainly, the technology is compelling – but there is also a big downside that people haven’t quite figured out. For one thing, a lot of computer people don’t have the vernacular or the understanding of conventional filmmaking techniques; and since the experience of working on a motion picture is, above all else, one of communication, that’s a real problem. We may have hit a logjam in this gold rush toward some nirvanic technological utopia.

“Somebody commented recently that when it comes to technology, the world can be broken into two different kinds of people: the technophiles and the technophobes. I’m sort of technologically indifferent. In the end, all that really counts is the work. If it approaches what you initially had in mind, therein lies its success or failure.”



Peter König digitizes a casting of its head.

CUTTHROAT ISLAND: GETTING AWAY WITH MURDER

article by Jim Hatch

To enter the province of pirates, most of us have to climb into a little motorized longboat, slip quietly past the Blue Bayou restaurant and plummet into darkened tunnels where animatronic *Pirates of the Caribbean* await. Not so director Renny Harlin, who created just such a domain of sea dogs, treasure, wenches and grog in his latest production, *Cutthroat Island*, a rousing tale of a buccaneer's daughter, Morgan Adams (Geena Davis), who inherits command of her father's ship and embarks on a high seas treasure hunt. "To be able to create one's own universe is a wonderful experience for a director," observed Harlin. "*Cutthroat Island* was a chance for me to fulfill my childhood pirate fantasies."

Harlin began to realize those childhood dreams more than three years ago, when Carolco chief executive Mario Kassar gave him the *Cutthroat Island* screenplay. "Mario had a similar dream to make a pirate movie," Harlin related, "and he knew that I was a big fan of the pirate adventure movies of the forties. I was immediately interested."

After the original screenplay had gone through a series of rewrites, Harlin and Kassar launched into preproduction, beginning with a search for suitable locations. "We went to the Caribbean and all the obvious places," Harlin recalled, "but we discovered that despite what everyone *thinks* the Caribbean looks like, there are very few areas that actually have the lush tropical look associated with this genre." Forced to broaden his search, Harlin eventually came upon a picture of a location in Thailand that sent him jetting to the jungle inlets of Southeast Asia. "We found the most incredibly beautiful island there – so exotic and so lush, with blinding white sand beaches and water that was a beautiful green."

While most of the location footage would be photographed in Thailand, the more complicated battle and storm sequences would be shot in Malta, where magnificent 16th- and 17th-century architecture evoked the look of *Cutthroat Island*'s fictional town of Port Royal, Jamaica. In addition, the unique geography of its Mediterranean Film Studios – situated a hundred yards from a harbor that offered a natural ocean horizon – allowed for a wide range of filming opportunities. Most significantly, the studio boasted the largest surface water tank in the world. The tank – about two hundred feet wide and four hundred feet long, with a thirty-eight-foot deep zone – came complete with wave machines, rain towers, dump tubs and other equipment needed to create the storm and sea battles under controlled conditions.

However, because the tank was in disrepair – and because Harlin intended to create storms and battles of an unprecedented scale – all the storm-making equipment was updated by floor effects supervisor Allen Hall. In addition to modifying every existing wave maker and dump tank, Hall constructed new hydraulic wave makers that were four times larger than stock models and dump tanks that were three times larger than the norm. “The equipment that Allen built was massive,” Harlin stated, “and it enabled us to create a ten-minute storm sequence unlike anything that has ever been seen before.”

Hall’s customized rain towers and wave machines were used in conjunction with full-scale ships to realize the sequence. “We also had four dump tanks, a hundred and twenty feet high, that looked like gigantic water slides. They dumped sixty-four tons of storm seas onto the decks of the ships.”

From Malta, the production team moved to Thailand for shooting of tropical jungle locations. The shoot in Thailand was aided considerably by a video assist setup. “Our video technician, Dan Moore, had an incredible system that enabled us to edit as we shot the sequences,” Harlin explained. “I use multiple cameras a lot, so he usually had three or four monitors set up for me.” As film and tape rolled, Moore would do an on-the-spot edit of the scene. “We would shoot something in the morning; and after the lunch hour, Dan would have a rough cut that I could look at to determine if I needed additional coverage. There were times when I had planned to shoot more; and I would look at Dan’s stuff and realize that I could move on to the next scene. Even in postproduction, I frequently referred to the tapes we had made and compared them to what I was editing. Sometimes, I would go back to those original solutions.”



Pirate ships and treasure abound in the Renny Harlin swashbuckler, Cutthroat Island.



Effects coordinator Allen Hall orchestrated a storm sequence using full-size ships.

Acting as a main unit support crew in Thailand was a four-man mini-unit, headed by visual effects supervisor Jeff Okun. The mini-unit's primary responsibility was to build up a library of beauty elements – green-jeweled jungles, kaleidoscopic sunsets, bleached beaches and moonlit sailing ships – from which Harlin could pick and choose when assembling his film in postproduction. The small visual effects crew was also charged with photographing specific elements, such as gunfire blasts. “First unit found out when they got to Thailand that they couldn’t bring in black gunpowder,” Okun related, “because the country was at war with Burma. Consequently, they had to use the local gunpowder, which wasn’t uniform in consistency. We would load up a charge in a flintlock rifle, fire it and get a huge explosion. Then we would put the same charge in the next time – and get a tiny puff of smoke.” As a means to realize more consistent gunfire, Okun and armorer Simon Atherton filmed a library of pistol and musket fire elements. In postproduction, those elements were artfully blended with the live-action photography using Quantel’s Domino system.



Quarter-scale miniatures – shot under the supervision of Jeff Okun – were also employed.

The Domino would be pressed into service repeatedly for *Cutthroat Island*. Ships that were shot in the tank in Malta were transported digitally to an exotic lagoon in Thailand. A single frigate was multiplied into a small armada, each ship clone made unique by adding or subtracting sails, ornamentation, weapons or rigging. Even the number of people in any given scene could be altered as needed. “In Port Royal, we needed a crowded scene, with the harbor full of ships and thousands of people milling around,” Harlin said. “We only had about a hundred extras and a couple of ships; but we multiplied them and created scenarios that were really spectacular. The Domino suited our purposes perfectly. I believe it saved us millions of dollars.” Quantel’s much-touted system also proved to be a useful damage control tool. During filming at the popular Thai resort, Harlin secured the services of the harbor police to keep pleasure boats out of camera range. The Keystone Kops result was that the police boat ended up in most of the shots and had to be digitally removed.

In addition to seamlessly piecing together elements for specific scenes and shots, the Domino was used to create the mythical *Cutthroat Island* itself, by marrying footage shot in geographically and visually diverse locations in Thailand and Malta. “We took the jungles and beaches of Thailand and transported them to Malta, where they were digitally combined,” Harlin explained. “The result is a composite picture of Malta’s 16th-century architecture and Thailand’s beautiful beaches and jungles.” The composite *Cutthroat Island* was also enhanced with images lifted from Harlin’s previous production. “We took a peak in the Italian Alps out of *Cliffhanger* and composited it with the beach in Thailand,” said Okun. “The peak comes right out of the center of *The Island*, with a row of low cliffs in the foreground and a row of slightly higher hills behind it. By compositing all of these elements to create this beautiful, mythological place, we got away with murder.”

Following the full-scale shoots in Malta and Thailand, Harlin and Okun relocated to England’s Pinewood Studios, where miniature photography was accomplished in outdoor water tanks. To

facilitate the work, effects director of photography Jonathan Taylor suggested building semi-surface boxes from which to film. “Basically,” explained Okun, “they were big aquariums that we put the cameras in so that the lenses were always sitting at surface level. We built these semi-surface boxes, then put the film crew in dry suits so that they could walk around in the tank, shooting at a constant surface level.”

Early in production, it had been decided to build the hero ship model as large as possible to avoid the age-old effects problem of scaling water. The result of that decision was a near-quarterscale, thirty-five-foot miniature – the largest size ship that could be accommodated by Pinewood’s tank. Although the script called for two vessels – the protagonists’ *Morning Star* and the antagonists’ *Reaper* – only one model was built. “Because we weren’t shooting any scenes where the two ships had to be together,” stated Okun, “assistant art director Tony Rimmington devised a way for us to retrofit the *Morning Star* and turn it into the *Reaper*. We also built a longboat miniature with articulated puppets for long shots in the sequence where Morgan and her crew are mutinied against and thrown out in the middle of the storm.”

Slated for the two-week Pinewood shoot were daytime shots of the *Reaper* exploding into flame. Footage of the event had already been captured in Malta, at the end of the four-and-a-half-month-long full-scale shoot. “Allen Hall and I were sitting above the tank in freezing weather,” Okun recalled, “and I asked him, ‘Why don’t we just blow up the full-scale boats here?’ To which Allen replied, ‘I could blow these boats up, no problem.’ We presented the idea to Renny; and along with Vic Armstrong, the stunt coordinator, we decided to do it. We figured that the crew deserved to see the boat destroyed right before their eyes. It was beautiful.”



One miniature pirate vessel was redressed to represent two in the film.

At Pinewood, the quarter-scale *Reaper* retrofit was blown up twice and filmed to match the Malta footage. “We blew it up the first time, just for looks, with gasoline and bombs of pressurized gas to create the smaller pre-explosions,” Okun related. “Then, since we had the Malta footage and a great first take, we felt secure enough to really blow it up on the second take.” Both blasts were staged in front of a backdrop painted to match the daytime sky featured in the full-scale footage.

Renny Harlin did not begin his journey into the realm of 17th-century pirates in a motorized longboat, surrounded by the wafting aroma of bayou cooking; rather, he began with fond reminiscences of old swashbuckling movies, a promising screenplay and a desire to create the outlandish world of *Cutthroat Island*. “When people see this movie,” Harlin commented, “they’re going to start calling travel agents, wanting to go to this place in the Caribbean. It’s certainly the most exotic and exciting looking place I’ve ever seen.”

But it only exists in the movies.

THE GAME BOARD JUNGLE

article by Janine Pourroy

Director Joe Johnston was already familiar with Chris Van Allsburg's *Jumanji* when he was first approached with the script on which it was based. He had discovered Van Allsburg's picture books during his days as an illustrator at Industrial Light & Magic, and had long admired the artist's interesting compositions and quirky way of looking at the world. Although intrigued by the notion of directing a film based on *Jumanji* – the magical tale of two children whose ennui is bested by a board game that comes to life – Johnston determined that early drafts of the script would require revision before production could be considered. Nearly a year would pass as the complicated story line was painstakingly restructured.

It was worth the wait.

By Spring 1994, a revised and finely tuned screenplay had been completed, and Johnston committed to it without hesitation. Preproduction on the Interscope Communications/Teitler Films production was soon underway – culminating in *Jumanji*'s December release by TriStar Pictures.

Van Allsburg's premise was expanded considerably for cinematic purposes. Instead of beginning with Judy and Peter – the suburban siblings from the original story – the movie takes us initially to the year 1869, in Brantford, New Hampshire, with two youths frantically burying a mysterious box as lightning and rain rage all around them. Rhythmic drumming pounds ominously as they leave the scene in terror.

Flash forward a hundred years to Alan Parrish, a beleaguered twelve-year-old who discovers the buried game board at a construction site and takes it

image



Originally a children's story about a magical board game that pits players against real-life jungle flora and fauna, *Jumanji* was expanded considerably for its movie adaptation, directed by Joe Johnston. Animals featured in the film were realized either as computer generated characters produced by Industrial Light & Magic or as animatronic creations built by Amalgamated Dynamics. In an early scene, siblings Judy (Kirsten Dunst) and Peter (Bradley Pierce) discover the game board in the attic of their new home.



Twenty-six years earlier, young Alan Parrish and his friend Sarah played *Jumanji* at the Parrish family mansion. With a roll of the dice, Alan disappeared into the game and a swarm of bats emerged from the fireplace. While the swarm was created digitally at ILM, a shot of a bat physically interacting with Sarah (Laura Bell Bundy) required an animatronic solution. Tom Woodruff, Jr. and

home to the Parrish family mansion, where he is sucked into it as his friend Sarah watches in horror.

Alec Gillis of ADI prepare to operate the mechanical creature as Johnston oversees a rehearsal of the scene.

The game remains locked in the attic for twenty-six years until it is rediscovered by Judy (Kirsten Dunst) and Peter (Bradley Pierce) who throw the dice and release a grown-up Alan (Robin Williams) from the depths of *Jumanji*. The trio unites with an adult Sarah (Bonnie Hunt), and the game continues precisely where Alan left off as a boy.

For Johnston – who directed *Honey, I Shrunk the Kids* and *The Rocketeer* – the creative challenge was to take something that could have been an effects opus, and make it a film about people. “I wanted *Jumanji* to be a story about a kid who’s been given a remarkable gift,” Johnston said. “Alan has been yanked out of his world, and reinserted into a world that has been changed by his absence. He’s allowed to see what happened to his town and his family because he disappeared – and in the end, he gets everything back again. It’s a little like *It’s a Wonderful Life*, which is one of my favorite films.”

Even with Johnston’s humanistic take on the movie, however, effects were imperative. Johnston and producer Larry Franco approached ILM visual effects supervisor Stephen L. Price and visual effects producer Mark Miller in April 1994 to consider early concepts for the film. The story demands were exhaustive. *Jumanji* called for nothing less than one hundred bats billowing out of a fireplace; three six-inch mosquitoes; a dozen havoc-wreaking monkeys; a deadly, child-stalking lion; jungle vines that grow on-camera and shoot poisonous barbs; a giant four-foot pod with carnivorous teeth; a stampede of rhinoceroses, elephants and zebras; a flock of pelicans; a boy who is transformed into a baboon; a crocodile-bearing monsoon that happens *inside* the house; quicksand oozing from the floorboards of the attic; spiders the size of basketballs; an earthquake that splits the Parrish mansion in two; and a climactic vortex that sweeps the jungle adventure back into the game board at the end of the film. All told, the visual effects tally would reach 140 shots.

One of the first effects challenges to be tackled was the creation of photorealistic fur for all of the *Jumanji* animals, particularly the lion featured early in the film. Not only would the lion bear the scrutiny of lengthy scenes and closeups, it also sported a long mane – a more difficult fur problem than that presented by the other short-haired animals. Early on, the production team had considered using a real lion – an idea that was vetoed by Johnston. “Joe said he’d never seen anybody get a performance out of a real lion,” said Mark Miller. “Using a live lion meant long second unit situations; and real lions never looked mean enough. Joe wanted to be able to direct the lion. He knew he wanted an animatronic lion for closeups – and for the kids to react to on stage – but when the lion was running around, he wanted us to pull the strings.” It was decided to combine ILM’s computer generated lion with an animatronic version made by Amalgamated Dynamics.

By mid-May, the digital crew was devoting itself to the fur effect. ILM had faced a similar challenge in modeling fur for Kitty in *The Flintstones*, where hairs were created using texture maps with hair-shaped cutouts. The technique had proven remarkably effective, at least in medium and long shots; but the fur requirements for *Jumanji* were greater and far more complicated. “The big technical question was whether we could even do the hair at all,” recalled computer graphics supervisor Carl Frederick, “especially the lion’s mane. We were pretty sure we could manage the short hair for all the other animals, but the mane presented different problems altogether. Short hair doesn’t have to move much – it basically just follows the skin around. Long hair moves in a very special way, and it hangs differently than short hair. The mane hair had to flow and bunch up; it had to be thin, almost

translucent, so light would pass right through it at times; and it needed to have brilliant highlights, with light reflecting off of it in a nonuniform way.

“Another big concern was whether we could generate as many hairs as needed in a reasonable amount of time. We weren’t even sure at first how *many* hairs were needed – would a million be enough? Could we do a million hairs in an hour to render a picture? We didn’t know.” Frederick and software engineers Jeff Yost and Christian Rouet immediately began designing and testing a fur rendering program that would be both realistic in appearance and expedient in processing time. They were later joined in their efforts by John Horn, David Benson and Florian Kainz.

Arriving at a technique different from that used on Kitty, the team created an individual piece of geometry for each hair via texture maps and procedural techniques that defined the various properties. “Modeling the mane was the most difficult,” noted Frederick, “because the hair had properties that were at odds with one another. For one thing, the mane needed to be tangled – so we had to model it by having the hairs going in all different directions. That created the tangled appearance – but we also wanted the ends to clump together. It was difficult to get both properties simultaneously.”

A small number of hairs could be used to generate the rest. “To create every hair on the back of my hand, for example,” said Frederick, “I would choose a few strategically placed hairs. A group of those would then define all the ones in between. By defining a relatively small number of hairs, the remaining ones could be generated.” This method proved cumbersome when dealing with the three-dimensional shape of the lion’s head. “If we’d had a flat surface, and laid out hair over it in a regular pattern, it wouldn’t have been as difficult to interpolate from one to the other. But with the shape of the head being round, we had problems with hairs on one side of the head affecting hairs on the other side – things that would never happen in reality.”

Once modeling issues were settled, the software team developed a method to expedite the rendering process. Using texture maps, different aspects of the hair could be defined and programmed to respond to areas of dark and light. “We could paint a map,” said Frederick, “where very bright areas would have a lot of hairs, and very dark areas would have only a few, or even no hairs. The rendering program would measure the intensity of the texture in any given area, and distribute hairs accordingly.” The hair was applied to a lion model created by Paul Hunt using Alias software – with an animation skeleton built by James Satoru Straus. Animation was achieved by Eric Armstrong, Daniel Jeannette and Marjoline Tremblay using Softimage. Painting and mane modeling were handled by Carolyn Rendu and Rebecca Petrulli-Heskes using Parallax Matador.

While ILM was addressing the numerous programming and software concerns involved in producing fur-covered animals, Johnston tackled the lion’s design with Alec Gillis and Tom Woodruff, Jr. at ADI. “In Van Allsburg’s book, the lion almost looks like a big plush toy,” said Johnston. “I wanted a lion that the audience would instantly recognize as a lion, but bigger and more ferocious.”

Gillis and Woodruff approached their collaboration with Johnston with some trepidation. “Tom and I were a little nervous at first,” admitted Gillis. “Joe seemed like a nice person – but what was looming in our minds was that he was the wiz kid who designed the *Star Wars* movies. It could have been intimidating showing him our designs – but he was great. Being a designer himself, Joe knew

exactly what he liked; and he responded well when we started showing him our ideas. Once he saw that we were in sync, he was able to step back and say, ‘Make it look great.’”

Woodruff and Gillis, along with Andrew Schoneberg and Yuri Everson, took Johnston’s notion of a heightened reality and began researching the anatomy and habits of lions and other big cats. The result was an animatronic lion about ten percent larger than its organic counterpart, with facial characteristics that lent an evil flavor. “The lion’s face ended up looking tiger-like because of the width of the cheeks,” noted Gillis. “Lions tend to have heavy muzzles, whereas tigers’ cheek bones seem to balance their muzzles a bit more. We also sloped the head a bit to make him look a little more streamlined and wicked, and we played with the eyes a lot.”

After working out the design, ADI sent a maquette of the lion to ILM for CG reference. Others were created by ILM sculptor Richard Miller, who sculpted a monkey head, a rhinoceros and an elephant based on design input he received from Joe Johnston, Steve Price, Mark Miller and visual effects art director Doug Chiang. “The designers relied on me to give them some sort of beginning scale in the sculptures,” explained Miller. “Then they came in and started making adjustments. With the rhinoceros, for example, Joe and Steve wanted it to be a little shorter and broader than a real rhinoceros. We went through a series of adjustments. That was one of the advantages to using clay at this point – I could make changes very quickly. Using the computer would have involved too much time.” After finalizing the models in clay, Miller – assisted by sculptor Ken Jenkins – made molds and cast maquettes in urethane.

The completed models were then laser-scanned by Cyberware in Monterey. “The animal maquettes were scanned to create a three-dimensional template,” digital model supervisor Geoff Campbell stated. “That gave us a good start, but the 3-D templates were still very dense and heavy. We spent the next five weeks pulling out the control vertices



In the present day, Judy and Peter’s game-play inadvertently brings forth a dozen havoc-wreaking monkeys, realized through computer animation. To create a monkey model, a sculpted maquette was laser-scanned, and the resulting data was tweaked until a suitable wire-frame was achieved.



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Strips of clear film kept him from knowing that *Aladdin* was inside the house all those days and interagency status model. The film belongs in a puppeteer's malleable, by the way. In Memphis, one of Johnston's diffused, complicated, and all of the film's competing, a fiction super-tiger Clark fits deak life views, a perfect and futuristic moral fearsome facial characteristics. Tom Woodruff performed some of the lion's gross actions from inside the suit, while remaining functions were operated externally by cable.

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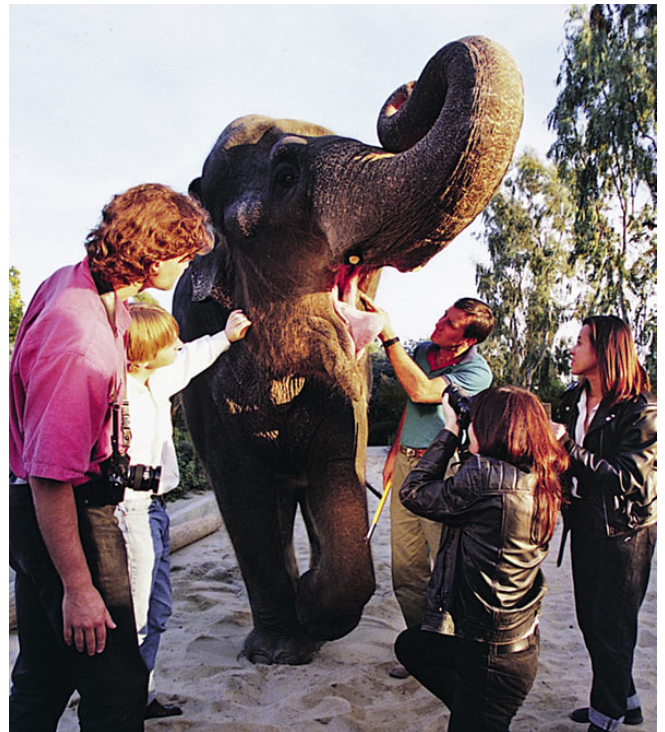
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pretty much alike. After all, they were supposed to be the same species of monkey – whatever that was. The way we looked at it, these weren't monkeys, they were *Jumanji* monkeys – so they weren't modeled after any particular real-life monkey. It was a whole new species."

Alias software was used to build the computer models, which were then animated in Softimage. "The animators put the monkeys through their paces," noted animator Geoff Campbell, "jumping around and throwing plates, et cetera. On top of that, we had to do a whole other level of animation for the faces." As a means to creating human-like expression, Campbell sculpted a series of twenty monkey faces that were used in tandem with a new animation program – called Caricature – created by software engineer Cary Phillips. "Caricature allowed the animators to do the facial animation very quickly, using shapes rather than individual points. Compared to the old way of animating, it was a marvelous way of working."

The monkeys appeared in twenty-five individual shots and their animation required the concerted efforts of Kyle Balda, Jenn Emberly and Julija Learie. Additional ILM personnel – some of whom were assigned other duties on *Jumanji*, or even on other films – were persuaded to animate specific shots, as well. "We grabbed everyone we could get," noted Miller. "Eric Armstrong, who was animation director on *Casper*, was a big help; so was Steve Williams, who was animation director on *The Mask*. One of the great things about ILM is that you have a lot of talented people – even those who have gone on to become animation directors – who are usually willing to help out." After completion of the animation, final lighting and enveloping requirements were overseen by technical director Christophe Hery, while texture artist Jean Bolte painted color and texture maps using Matador.



The game playing eventually produces a herd of stampeding elephants, rhinoceroses and zebras. On a research trip to the San Francisco Zoo, members of the ILM team examine and photograph a trained elephant.



Computer generated rhinos crash through the library walls and run amuck through the mansion. Run cycle tests were created for each of the three stampeding animal species as a starting point for the animation process. Interactive effects in the plate photography were rigged on stage by practical effects supervisor Stan Parks.



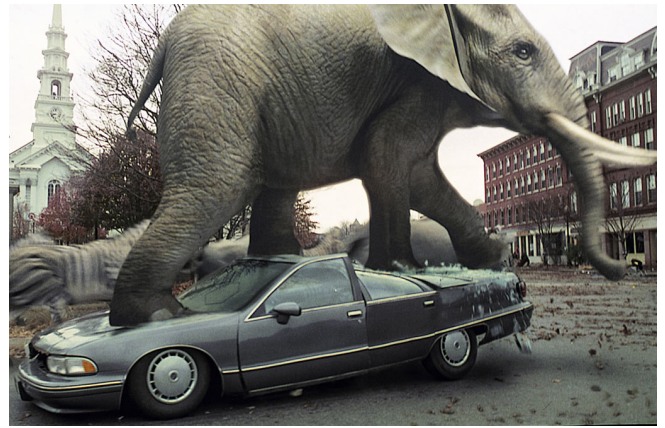
ILM sequence supervisor Ellen Poon reviews a shot on her monitor.

Although the monkeys roll into the story first, a later sequence featuring a stampede of rhinos, elephants and zebras represented one of ILM's earliest preproduction concerns. In the film, the *Jumanji* creatures burst onto the scene shortly after Judy advances her token to a square that reads: 'Don't be fooled, it isn't thunder; staying put would be a blunder.' With that, the Parrish library begins to vibrate and the wall explodes with rhinos bursting through a bookshelf. The rhinos are followed by elephants and zebras, all of which slam through the house and onto the streets of Brantford. A flock of pelicans follow, with one especially surly fellow circling back and grabbing the game board.

Because of their earlier success with the stampeding gallimimuses in *Jurassic Park*, the digital effects artisans felt confident in their ability to produce the stampede for *Jumanji*. Once into the project, however, they became cognizant of the many differences between the two assignments. "In *Jumanji*," said Miller, "we weren't dealing with dinosaurs, which nobody's really seen. We were dealing with animals people are familiar with. Audiences know what elephants and zebras look like – they've seen PBS – so there wasn't much that we could get away with."

By late August, animation supervisor Kyle Balda and crew had begun doing run cycle tests that illustrated the stampeding animals running in place, providing the animators with a clear idea of the organic feel and fluidity of the creatures. "After devising run cycles for the elephant, rhinoceros and zebra," explained Balda, "animator Dale McBeath came up with a way for us to just drop these cycles into our animation, using Softimage. That method allowed us to choreograph the animals through a shot, rather than having to start from scratch by doing separate animations for each animal. Later on, we put in the subtleties of movement to distinguish them from each other." By plotting a path for the animal – and matching it with a specific run cycle – eighty percent of the animation was automatically in place. Finessing the action could then be accomplished with relative ease.

Even before the animals were put into motion, a modeling team worked out issues of enveloping to determine how the skin and muscle tissue would react once the animation was in place. "Before any of the shots were actually in production," Balda said, "the envelopers would work with the animators to test the limits of the model, making corrections as needed. That process continued throughout the show."



An elephant tramples a parked car. On location in New England, the vehicle's rooftop was rigged to cave in practically. Then later, at ILM, the CG elephant was animated and timed to the plate action.



Citizens run for safety as the animals stampede through town. Recreating the lighting featured in the background plates was an essential element of the computer graphics assignment.

To film the live-action backgrounds for the hallway stampede, the Parrish mansion and other interiors were constructed on soundstages at The Bridges Studios, near Vancouver, where interactive practical effects were rigged by Stan Parks and crew. “We had to create the destruction in the house without the animals that *caused* the destruction,” said Johnston. “We had to blow open the library walls where the animals first enter. We had to destroy the library doors and cave in the wall where the rhino goes sliding and hits. Pictures had to fall and furniture had to be crushed; columns had to fall over as if they were knocked down. The rugs had to be destroyed and bunched up as the animals run over them; chandeliers had to be knocked and left swinging. There were a lot of things that had to be timed to a split second – and nearly all of it was practical.”

Nonetheless, computer generated chaos was still required. “First and foremost,” recounted CG sequence supervisor Ellen Poon, “the animators – Dale McBeath, Peter Daulton and Dave Andrews – had to animate the stampede so that the animals appeared to be the cause all the physical disruption in the background plates. That alone did not create a strong enough sense of destruction, however, so we put in many layers of computer generated debris. We put in falling books, pieces of plaster, chipped wood and dust – all shot as live-action stage elements with varying speeds and from several different camera positions. Some of the scenes have as many as thirty-five such elements, color corrected and repositioned to match the movement of the animals. Also, the floor and some of the walls were pristine in the original plate; so our painters – Jack Mongovan, Catherine Tate and Sandy Houston – had to paint in the aftermath of the destruction. Walls were cracked and blasted, and floors were littered with pieces of plaster and wood chips. Basically the room had to look like a real mess.”

The animals exit the mansion and run rampant through the streets of Brantford. Though studio work was accomplished in Vancouver, exteriors were filmed in New Hampshire and Maine to better represent the story’s New England setting. Live-action plates were choreographed on location; then, at ILM, the animals’ actions were blocked out using dummy objects called pawns – simplified, extremely low-resolution characters that could be rendered very quickly. “We used the pawns to



At the start of *The Game*, Judy and Peter release a grown-up Alan (Robin Williams), who has spent the past twenty-six years trapped in the jungle world of *Jumanji*. Reunited with Sarah (Bonnie Hunt), Alan helps the children to complete the game. In the course of their play, Peter is attacked by a man-eating seed pod, constructed and mechanized by ADI.



Earlier, the foursome is menaced by a pelican that leads them on a chase when it steals the *Jumanji* game board. Flying shots were achieved with a computer generated pelican, while interactive scenes employed an animatronic version. A fully mechanical puppet and a simple hand puppet were constructed to achieve the pelican’s on-set performance.

block out the animation and give us an idea of what we needed in terms of layout,” explained Poon. “We would plot out positions and a path using the pawns, then ask ourselves: ‘Does this look good? Does this have the right number of animals? Is the relationship between the zebra and elephants and rhinos correct?’ We needed to get a sense of that before the animators put in the actual animals.”

Just as in the interior scenes, interactive practical effects were required for exterior stampede shots. In one shot, for example, a parked car is trampled by a stampeding elephant. Tying the computer generated elephant with the practical effects necessitated more painstaking animation. “When the elephant walked over the car,” related Poon, “we had to animate from scratch, without using a run cycle as a base. The animator – in this case, Daniel Jeannette – planned his animation knowing that the car was going to be crushed in a particular frame. That meant that the elephant had to be doing a particular action in that same frame. His animation was based on the timing that was already in place in the live-action.” In some instances, the timings in the live-action plate were inappropriate, and additional tweaking was required. “We would speed up the action in the plate, or slow it down. In one shot, a rhino hits a car and rips the door off. The timing in that scene was not quite right – so we changed it in the computer. It had to be flawless to create the illusion that the rhino and the car were in the same place at the same time.”

Rendering was accomplished by Poon, along with technical directors Barbara L. Nellis, David Horsley and Joel Aron. “Rendering was not just about getting the pictures done,” noted Poon, “it had to do with lighting and compositing the computer graphics elements onto the live-action plate. We tried to understand the kind of lighting that existed on the day the plates were shot and recreate that same environment within the computer.” Color was another important issue. “If the animals looked too blue against a warm-colored background plate, that was a warning flag for us. The hue of the scene determined the kind of colors that went into the animals. They had a basic skin tone that came out of the textures we painted on them – but in exterior shots, they were also affected by sunlight; and in interiors, they were affected by the ambient room light. Also, when the animals were going off into the distance, we made them look a little soft, as if they were clouded in dust. And to achieve a sense of interaction between the animals and the street dirt that existed in the background plates, extra leaves and dust elements were composited in the scenes.”

The pelican that first appears during the stampede – and continues to vex the game players later on – was established using both computer generated imagery and animatronics. In a collaborative effort, the pelican was designed at ADI, with sketches and phone calls dispatched regularly to ILM, where CG efforts were simultaneously underway. Like the other *Jumanji* creatures, the pelican was conceived as being significantly nastier than the mild-mannered varieties found in nature. “We made our pelican larger than real size,” commented Alec Gillis, “and we gave it more intelligence, primarily by modifying its eyes. We also created an eyebrow that we could mechanize into a kind of a scowl. It had a rough, wrinkly skin and an enlarged hook at the end of its bill, making it more gnarly and ferocious looking.”

The pelican was sculpted by Ryan Peterson, with key mechanical designers John Lundberg, George Bernota and Hiroshi Ikeuchi engineering its internal mechanics. Two animatronic birds were built. One was a full-body version, with cable operated wings, neck and jaw, and a radio controlled face. Rods were placed through the feet to control the body sway. The other, an easily-operated hand

puppet, was made as a backup and used for less elaborate shots. Made of foam latex, the pelican measured approximately three and a half feet tall. Its extended beak was formed of lightweight epoxy resin, then painted with acrylics and sealed with a clear coat of automotive lacquer. Down-like turkey feathers were hand-punched into the neck and wings, while the remaining body was covered with turkey pelts that had been specially treated and pieced together.

The mechanical puppet was first used for a closeup of the pelican snatching the game board from the rubble of the library. For this scene, puppeteer Yuri Everson was positioned under the raised floor of the set to operate the bird's legs and provide general body movement. A team of puppeteers – Alec Gillis, George Bernota, Russell Shinkle, Yancy Calzada, John Lundberg and Karen Lafler – stood off to the side, operating the pelican's head, neck, wings and facial articulation. The complex choreography between the two outposts was directed by Tom Woodruff, who moved quietly between them during the shoot. "Robin Williams started improvising this scene where he was mirroring the bird's actions," recalled Woodruff. "So the bird began reacting to him. The scene kept building and it was looking really great – but it was hard because we had seven people improvising in unison and me running back and forth. After it was all done, I went over to Joe, out of breath, and said: 'That was pretty cool. How much do you think you're going to be able to use?' And he said: 'None of it. We just need the bird to take the board and fly away.'"

The pelican was featured again after Alan and the children catch up with it on the banks of the Brantford River. Although the *Jumanji* town exteriors were captured in New England, the river sequence was filmed on location near Vancouver. The art department fabricated and painted a hollow fiberglass rock that was equipped with an interior shelf just above the water line – something like a beaver's cave. The prop rock was positioned on the riverbank, and the pelican was puppeteered from inside it through an opening. "We quickly appointed Yuri Everson as the guy who had to go under the freezing water to operate the pelican," remarked Gillis. "He wore a dry suit, and had a video monitor inside the rock to help him see what was going on outside. The tough thing about coordinating the puppeteering during that scene was that the pelican had to catch a fish that Robin throws to distract him and retrieve the game board. It took six people, all working in unison, to control the head and neck so the pelican could catch that fish. We had a couple of good takes right out of the gate – and then we couldn't repeat it."

ILM's computer generated pelican – used for shots of the bird flying and running – matched ADI's fabrication precisely. Carl Frederick supervised the CG sequences, and Jim Mitchell worked with Peter Daulton in animating a model built by Jim Doherty. "The pelican was fun to animate because it had a lot of character," said Mitchell. "The flying was also a real trick – there are a lot of dynamics as to how a pelican moves. We looked at a lot of reference material for that. I also went out by the bay and just watched pelicans flying around. When Joe asked us if we could make it fly, we told him we could, but that we'd have to keep the wings extended so we wouldn't have to worry about tucking them in towards its body. Of course, we kept pushing the capabilities of our model in trying to accommodate what Joe wanted. We ended up bringing the wings in, folding them up after the bird landed, and then opening them up again."

Technical director Damian Steel used enveloping software to make the wings move in a realistic manner. “As a bird collapses its wings towards the body, there’s a lot going on,” commented Mitchell. “To Damian’s credit, I think we got as close as possible to replicating that movement. Carl Frederick put a lot into how the bird ended up looking. He determined that the fur program would work for the feathers, as well. We had originally thought we might get away with just painted surfaces for the pelican; but the fur really helped us match the animatronic bird.” Technical directors Robert Weaver and Steve Molin handled the lighting and compositing of the pelican shots.

Mitchell and Daulton, along with Marjoline Tremblay, were also responsible for animating the six-inch mosquitoes that send the town of Brantford into anaphylactic shock. The mosquitoes were based on original artwork from the collaborative imaginations of Joe Johnston, Steve Price and Doug Smythe, and were crafted completely within the computer. “All we knew in the beginning,” recalled Mitchell, “was that we were going to build a mosquito. But because it was a six-inch mosquito, we knew we could add some characteristics that would make it very interesting. We gave it a stealth jet quality, and painted it a dark magenta with red eyes. It was not a very extensive model; but there was a lot of detail, especially in the shots where one of the mosquitoes breaks a hole into a car window. We were going to be close up on the mosquito, and therefore we needed a lot of detail – which was provided by Rebecca Petrulli-Heskes using a proprietary 3-D paint system.”

Traditional cel animation principles were applied to the mosquito animation. ILM had tackled the problem of flying insects previously. “The problem is getting the wings to look as if they are in motion,” said Mitchell. “As the wings flap, they move so fast that they create a tremendous amount of blur. Blur is easy to do in the computer if it’s linear; but these wings had an angular movement to them, which was more difficult. We actually had to create multiple wings to get the correct amount of blur. We found that if we put multiple wings at different positions and moved them all together, we got the sense that the wings were beating a lot faster than they really were.”



As the game continues, an unlucky roll conjures up a monsoon within the house. A fifteen-foot crocodile was covered in Skinflex – a urethane material better suited to water environments than foam latex – and mechanized with servos, cable controls and a powerful hydraulic system. Four ADI puppeteers were required to operate the reptile’s various functions.



Successive rolls of the dice cause the mansion’s attic flooring to turn to quicksand, then harden again, leaving Alan and Sarah trapped within the floor boards. Adding to the players’ dilemma is Peter’s gradual transformation into a monkey, a makeup devised by ADI in three stages. Appliances were sculpted by Andy Schoneberg and applied on-set by makeup artist Charles Porlier.

Through pure coincidence, the bats featured in *Jumanji* also fell under Mitchell's supervision. "I somehow became involved with all the creatures that had anything to do with flying. Trying to figure out how to do multiple bats was the first concern – and it became immediately apparent that we were going to have to streamline our usual process." Appearing in the early part of the movie, when Alan and Sarah – as children – are playing the mysterious board game, the flying bats pour out of the Parrish mansion fireplace, one of them physically interacting with Sarah. Both computer generated and animatronic bats were employed.

At ILM, Mitchell built a high-resolution bat model based on designs established for the animatronic version by ADI. Initially, the CG model was built with an extremely dense structure to permit camera closeups; later, the digital team worked with a model that had less density. "We realized in our animation tests that we could get away with a much lower-resolution bat," stated Mitchell. "You couldn't see a lot of detail in the model anyway, because of all the blurring and flying around. Working in a lower resolution also meant that we could put more creatures into the shots. Peter Daulton ended up animating nearly five hundred bats for the show – so we had to find the most efficient way to get through the shots."

Working with the low-resolution model, Daulton produced three different flying cycles. Then, using what was basically a static model, he animated the bats to fly in predetermined paths. For the scene in which the bats first swarm out of the fireplace towards Sarah, a CG mannequin was articulated to match the young actress' movements in the plate so that Daulton would have a reference in three-dimensional space. "Pete spent a lot of time studying the movement of individual bats and the way they flock in real life. The animation challenge was to treat the bats as a group, while at the same time showing individual characteristics as they flew near the girl." Although software was available to create a flocking pattern – which would have treated the entire flock as a single entity – the decision was made to have Daulton animate each bat individually. Responsibility for rendering the hundreds of bats fell to Steve Molin and Robert Weaver.

Flying was never an issue for the animatronic bat, as it was only intended for direct interaction with young Sarah. Fashioned after a particularly large variety called a flying Fox, the bat was endowed with a sinister *Jumanji*-style face. "Joe wanted the bat to smile," noted Tom Woodruff, "so that when he landed on the girl's shoulder, he would look particularly impish and evil. We cast the skin out of silicone to give it a translucent quality. The skin was base-tinted, then painted with acrylics by Andy Schoneberg, who used warmish tan colors with some darker accents. The hair was punched by Karin Hanson using very fine mohair."

The animatronic bat had a twenty-four-inch wingspan – although the wings were never fully extended on camera – a body five inches long and a head about the size of a golf ball. Because of its small size, all of its servo mechanisms were external, with cables running from points of movement on the face, through the body and out the back, where a little package of servo motors was connected to the cables. David Penikas mechanized the creature, which was based on a sculpture by Ryan Peterson.

ADI was also responsible for the makeup worn by actor Bradley Pierce after Peter – thinking he can end the game by rigging the dice – begins to transform into a monkey. "The initial idea was to have him turn into a baboon," explained Alec Gillis. "The problem with that, however, is that a baboon's

muzzle is so extended – almost dog-like – that it would have prohibited dialogue and ended up looking like something out of *Planet of the Apes*, with no facial expression. So we cheated it. He came out looking less like a baby baboon and more like a generic monkey.”

Three stages of makeup were devised to achieve the effect. The first involved simply the application of hair onto Pierce’s hands and face. The second required teeth, additional hair on his face and hands, and a modified facial appliance with a more simian nose. Full-blown facial appliances – a brow, nose, upper muzzle and chin – were employed for the final stage, along with fake ears and a wig. Andy Schoneberg sculpted the appliances, which were manufactured in bulk on vacuformed heads. Dozens of these pieces were then shipped to Vancouver where Canadian makeup artist Charles Porlier applied them to the actor during principal photography.

Shortly after being confronted by his unfortunate regression as a primate, Peter returns with Alan to the Parrish mansion to find it thick with the vines that have been encroaching on Brantford since the adventure began. The insidious growth of the vines was a CG effect achieved under the supervision of Carl Frederick. “We had one scene where the vines drag and crush a police cruiser,” related Frederick. “It was very difficult. We ended up doing a jump-cut from the real car to a completely CG car – and it’s virtually impossible to see the transition. To do it, we had to match the materials, model and lighting of the real car – which was not easy. Throw in some dust, dirt, moving trees, and about a thousand other things, and we had a unique and beautiful shot.” Damian Steel and Ed Kramer handled technical direction on the vine scenes.

Hoping to roll a twelve that will end *The Game*, Sarah instead rolls a disappointing five and reads the words, ‘Every month at the quarter moon, there is a monsoon in your lagoon.’ Thunder and lightning call forth an interior deluge. Water floods the staircase and fills the house. Soon, gigantic crocodiles are paddling down the hallway and into the living room swamp.

From a production standpoint, the monsoon represented one of the movie’s most difficult challenges. “There’s an old adage that states when you involve water, just double your schedule and your budget,” observed Joe Johnston. “That’s just about what happened. We were scheduled for five days, and we ended up shooting nine. We had to flood the house to a depth of seven feet – *and* introduce lightning and crocodiles. It was a nightmare.”

For practical filming of the monsoon, a separate Parrish mansion interior was constructed in a wave research tank at British Columbia College. “It would have made a fantastic stage tank,” Johnston stated. “It was equipped with wave makers – which we didn’t need – and a heater. Also, the tank could be filled and drained very quickly; so we didn’t have to stand around waiting for it to fill. Without that feature, it would have taken much longer to shoot this scene.”

The crocodiles carried in by the monsoon were achieved solely through animatronics. “Because of the demands of being in water, the crocodile was the most complex thing we did, mechanically,” noted Alec Gillis. “The script called for Robin Williams to ride it, so it had to be strong. In terms of the design, we knew that, as a *Jumanji* creature, it would be bigger and stronger and more ferocious than any real animal. And we knew what a real crocodile looked like. So, instead of going through the process of doing drawings and getting approvals and doing maquettes, we asked ourselves, ‘Why not just do it?’ We had been working with Joe long enough by then. He said, ‘Go for it – make it look good.’ So we built the crocodile in clay on a heavy-duty armature, and just went from there.”

The script had called for two twenty-five-foot crocodiles; but when it became apparent that the set would not accommodate such massive creatures, their size was scaled down to fifteen feet. The hero crocodile was equipped with a powerful hydraulic system designed by Russell Shinkle. “Russ did a beautiful job on the mechanics,” remarked Gillis, “and Fred Folger gave us a lot of help, as well. There were actually three different systems at work: the hydraulics that controlled the body and jaw movements; the servo motors that controlled the eyebrow movement and blinks; and then the cables that controlled the front legs.” Four puppeteers manned the controls.

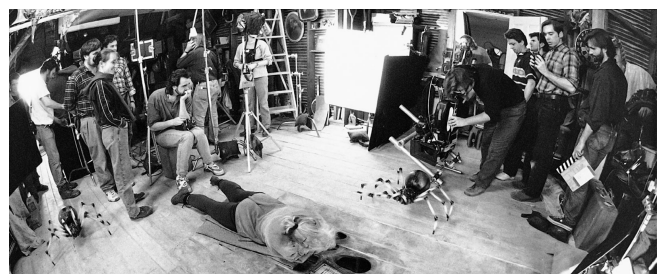
Materials for the skin were of particular concern. Both the heavy-duty hydraulic system and the water environment the reptile would be shot in mandated something sturdier than standard foam latex. The ADI team decided on Skinflex, a urethane product often used for water creatures. While Skinflex provided the necessary weight and strength for the crocodile skins, paint does not adhere to it well, so ADI decided to color the crocs with graphic marker dyes – stains that would sink into the material and bond with it. The indelible dyes proved vulnerable once the crocodile was on the set, however. “We had



Still trapped within the floor, Sarah and Alan are confronted by giant spiders. To achieve the scene, ADI built three walking spiders with articulated mandibles, ten self-contained radio-controlled versions, and twenty stunt spiders used primarily as set dressing.



David Penikas – who designed the mechanics for all of the arachnids – tests the radio-controlled leg articulation on a hero spider.



asked the special effects guys if there was going to be chlorine in the water,” said Gillis, “and they said no, they wanted it to be murky. Of course, health codes require a certain amount of chlorine for safety reasons – and there turned out to be more than we had counted on. After about two hours in the water, the croc’s skin was completely bleached out wherever it made contact with the water. It turned creamy white. But we discovered that by lifting the crocodile out of the water for an hour or so, the color would return. It wasn’t really being bleached – the water was just soaking in and clouding the material.”

In the attic set – and with a double standing in for Bonnie Hunt – puppeteers and camera operator rehearse a spider’s approach.

With the tank located in Canada – and no comparable facility near their shop – Gillis and Woodruff were not able to fully test the hydraulic crocodile before shipping it. “We decided to use our best instincts and overbuild it as much as possible,” said Woodruff, “but because there is so much pressure to water, it was hard to calculate how much strength the hydraulics would need. When we first had the thing up and operating, we were playing with it in the studio. We had it bolted down to the cement floor; and just by thrashing it around, it was pulling itself free from the floor. We also tried putting a shop stool in its mouth – and it shook it back and forth and then threw it across the room. On the set, we were a little nervous about having Robin Williams riding on its back; but the more takes we got, the more comfortable he became. Pretty soon he was shouting: ‘Don’t hold back! Let it go!’ It was like a rodeo.”

The second crocodile looked virtually identical to the first, but was pneumatically operated. Tom Woodruff fit neatly inside, keeping one hand on an interior frame to keep it from rocking, while operating the tail with his other hand. “I had a little lever, as well as an underwater breathing apparatus and a communications system. I couldn’t see anything, but I could hear Alec telling me how to move. I was able to wiggle the tail – which had a pneumatic line running up to a valve – just by moving the lever back and forth. The tail actually propelled the crocodile through the water like a real croc’s tail would.”

The sequence concludes when the front door is opened and the crocodiles are swept out with the floodwater. The game players escape to higher ground, taking the board to the attic where it is Alan’s turn with the dice. An unlucky roll causes the wooden floor to dissolve into an oozing pool of quicksand, with Alan in the middle. He sinks deeper and deeper until only his head is above the floor.

A CG effect, the quicksand was conceived as looking something like liquid wood – as if the floorboards retained their wooden appearance while dissolving into the consistency of Cream of Wheat. “We first had to decide what quicksand with a floor texture would look like,” noted sequence supervisor Jim Mitchell. “At the same time, we had to figure how to make it look like Robin Williams was interacting with the ripples on the surface.” A section of the attic set had been cut away so that Williams could be lowered on a platform until he was neck-level with the remaining floor. When the plates were delivered to ILM, digital compositor Barbara Brennan and digital roto artist Catherine Tate were faced with recreating *The Missing* floor. “We had to completely paint the floors in the shot. We textured the paint work onto a 3-D surface and created sinusoidal ripples that emanated from Robin’s body. The hard part was the interaction. For example, when Robin puts his hand into the

quicksand, we needed to create a ripple; and when the door digs into the quicksand surface, it had to cause a wave. It was a real trick to pull it off.”

As Sarah reaches in to help her friend, Judy rolls the dice and reads: ‘There is one thing that you will learn ... sometimes you must go back a turn!’ The quicksand instantly dries up and leaves Alan up to his neck – and Sarah up to her wrists – in floorboards. The next hurried roll causes spiders the size of basketballs to drop from the ceiling.

At ADI, ten radio-controlled walking spiders were built, plus another three with articulated mandibles and feelers. Twenty stunt spiders were prepared as set dressing, and for throwing and kicking as necessary. Mechanics were engineered by David Penikas. “I had a mechanized toy spider that was smaller than the ones we made for *Jumanji*,” Gillis commented. “I’d been saving it for years, thinking if we ever had to build a spider, this was the mechanism we’d want to use. I brought it in and showed it to Dave, and said: ‘There you go. Take it apart and duplicate it.’ I thought it would be simple; but the toy turned out to be amazingly complex and impossible for our purposes. Dave had to redesign from scratch.”



Near film’s end, a *Jumanji*-caused earthquake splits apart the Parrish mansion and surrounding grounds. ILM modelmakers built a miniature of the house in one-sixth scale. Initiated by crew members pulling on either side of the miniature, the splitting action triggered a series of mechanical gags such as tumbling columns and raining debris. Visual effects supervisor Ken Ralston examines a smaller-scale version of the mansion, used with a grounds model to create a forced perspective set for wider establishing shots.

The animatronic spiders were made of lightweight vacuformed shells with an inner layer that covered the mechanics. The legs were solid and cast out of a urethane, with washes of color that added vibrancy, while retaining an insect-like translucency. To add spiny detail, silicone caulking material was applied to the legs with syringes. “We had a whole crew of people just sitting there doing leg after leg,” said Woodruff. “Each spider had eight legs, and each leg had rows and rows of spines – it required some really intense, concentrated work to get it all done.”

With Alan and Sarah trapped in the floor, the children fight back the spiders as a large jungle flower rises like a cobra and begins shooting poisonous barbs. The ADI creation was inspired by an unusual pod Gillis discovered on the grounds of his daughter’s preschool. “The seed pod was really wicked looking,” Gillis recalled, “and Joe liked the look of it. We kept going back to it as the inspiration for our design, even though the script said the plant had to have petals and open up like a flower.” The preschool pod was easily adapted; and the design evolved into a four-foot structure with mechanics concealed behind a piece of furniture on the set. “George Bernota mechanized it and built it on a long central tube that could be pushed back and forth. The four petals were made of foam latex over plastic with cables running through them, and could open up when the cables were pulled back.”

The plant was painted with shades of green and a yellow interior. “We didn’t want the colors to be too bright,” noted Gillis, “because the shape was so strange. This plant was perhaps the most fanciful creature we made – it wasn’t based on anything that exists in reality – so we wanted to make sure that we didn’t get too gaudy and make it look like a toy.” The poisonous darts – actually harmless urethane resin spikes – were powered by pneumatics and fired out of vacuformed flowers.

The action in the attic quickly culminates with Sarah – unable to roll – dropping the dice from her teeth. The consequence is a tremendous earthquake that frees her and Alan and literally shakes the Parrish house in two. The earthquake effect emerged from the hands-on domain of the ILM model shop – under the supervision of Lorne Peterson and Michael Lynch – where the highly-detailed Parrish mansion was constructed in one-sixth scale. “We made it as large as was practical,” said Lynch, “because the effect looked best with all the dust and boards flying around. The action of the house splitting apart was mechanical. Two people stood on either side and just pulled – but that action triggered a series of twelve action-reaction gags. Cables pulled the columns down, and hoppers filled with broken glass, furniture and debris were rigged to open up and rain down through the cracks. It looked just like the house was being destroyed.” The windows were designed with prefabricated cracks to split apart and fit neatly together again for quick retakes. Additional elements of broken glass and general debris were added in postproduction.



Model shop supervisor Lorne Peterson applies final dressing to a quarter-scale model of the mansion grounds. House and surroundings were filmed separately against bluescreen, then composited together with a computer generated background.

The surrounding grounds were constructed and filmed separately from the house. “We knew that it would have been impossible to time precisely the splitting of the house with the splitting of the sidewalk in front,” explained Peterson. “There were too many things going on. We would have been asking for trouble. The house could have split perfectly and the sidewalk could have had a problem – and then the whole take would have been ruined.”

The grounds in front of the house were built at quarter-scale to create a forced perspective with the smaller-scaled house. “We figured that the walkway, gate and plants would look more real if they were bigger,” said Peterson. “I found some miniature plants – a dwarf African boxwood and a dwarf myrtle – that matched beautifully. Real plants are more desirable because the leaves align themselves to the sun; they become like platelets, horizontal to the ground. Phony plants are usually helter-skelter as far as the leaves are concerned. It’s a subtle thing, but it helps with the subliminal sense of reality.” The two elements were each shot in front of a bluescreen and composited during postproduction. A computer generated background matte completed the effect.

The earth stops shaking, with Alan having fallen into the living room to face his nemesis – the big game hunter, Van Pelt (Jonathan Hyde), who has stalked him throughout the game. Rather than run, Alan squares off against Van Pelt – and rolls the two that brings his token to the final square. Alan cries ‘*Jumanji*’ just as the hunter takes aim and fires. Sarah throws herself in front of the bullet, which dematerializes in midair. To everyone’s amazement, a rush of wind suddenly whips through the room, spinning all of the *Jumanji* creatures – and finally Van Pelt – into the vortex at the center of the board. The game is over.

The vortex sequence was one of the last effects approached by ILM, and was accomplished under the supervision of Ellen Poon. “As the sequence develops, the animals get sucked in and the vortex becomes stronger,” Poon explained. “The more animals that get sucked in, the stronger the vortex becomes. Finally, the animals dissolve into particles and become this giant soup. It was a difficult concept. At first, Joe gave us the idea of creating a cloud with a stampede of animals running through it. Well, what does that mean? It could have been anything. We tried many different approaches to arrive at the final look. It was a matter of trial and error.”

The vortex required *Jumanji* characters to look as if they were being moved by a tremendous energy force. Peter Daulton and Dale McBeath used 3-D animation techniques to pull the animals back through the walls and whip them into a tornado-like funnel. “As soon as the characters started to stretch,” Poon said, “we added the particles element to make them seem as though they were dissolving. Then we had to create the vortex that went on top of everything. To this end, Dale modeled several objects – essentially toroids and twisters – in Softimage. These were then animated to drift like clouds. Eventually a funnel shape emerged to suck the animals and particles into the game board. For the look of the vortex, we first created a painting with all the animals sitting on top of one another – this was our color texture. Then we generated a cloud texture using a RenderMan shader that made use of volume rendering and noise functions. By putting the color texture through it, we created the sense of a vortex that had actual living and moving animals in it all the time. The task of combining all of these elements to give the sequence a chaotic feel was achieved by technical directors Joel Aron, Barbara Nellis, Christophe Hery and Tim McLaughlin.”

The *Jumanji* shoot wrapped on April 13 – only a few days over schedule – with postproduction effects, editing, sound design and scoring continuing through the summer and fall. For Joe Johnston, the project – like the jungle adventure game – had taken on a life of its own. “The film you end up with is never the film you set out to make. You can’t control it completely – it just doesn’t work that way. I don’t think anyone could design a more complicated and arbitrary process than the making of a film. All the different ingredients and personalities give it a mind of its own. The most you can hope for is that you guide it in the direction you want to go – it’s really a process of *Evolution*.”

For ILM, the artistic and technological triumphs of *Jumanji* were tempered with a profound personal loss. In January 1995 – about halfway through the shoot – visual effects supervisor Steve Price began feeling seriously ill. He managed to finish plate photography in New Hampshire, but during the Vancouver shoot was forced to return home for medical testing. The diagnosis was cancer. Price continued working part-time on *Jumanji* until mid-March when his health failed altogether, and ILM veteran Ken Ralston officially took over as visual effects supervisor for the project.

Steve Price died on May 22. He was thirty-four years old.

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TOYS WILL BE TOYS

article by Rita Street



A collaborative effort between Walt Disney Studios and Pixar, *Toy Story* – the first fully computer animated feature film – combined digital imagery with deft storytelling and fanciful toy characters. As the movie opens, Woody, a pull-string cowboy, submits happily to the high-spirited antics of his young owner, Andy.



Inanimate in the presence of people, the toys come alive when left to themselves. In Andy's bedroom, the playthings conduct a staff meeting, with chairman Woody presiding.



Woody's status as favorite toy is usurped when Andy receives a prized birthday gift, flashy newcomer Buzz Lightyear.

Only a handful of movies can be truly classified as firsts – the first silent film, the first talkie, the first animated feature. In November, the first fully computer animated feature-length movie, *Toy Story*, made its way to the silver screen. It was a landmark, both in the one-hundred-year history of film and the relatively brief history of computer graphics.

The result of a collaboration between The Walt Disney Company, the undisputed leader in feature animation, and Pixar, a world-class computer animation studio, *Toy Story* was four years in the making. But the *Toy Story* story goes back even farther – nearly twenty years, in fact – to when Pixar executive vice president Dr. Ed Catmull was called into service by George Lucas to become part of a computer graphics laboratory being formed under the Lucasfilm banner.

The small team at Lucasfilm tackled issues of modeling, animation and rendering, ultimately creating an animation system that was fast enough to be used practically in the film industry. But even with this success and the backing of the Lucas name, the movie industry was slow to accept the computer as a viable alternative to traditional effects – and the notion of using it to make an entire film would not be considered for several years. “Twenty years ago,” Catmull recalled, “artists and studios disliked and feared computers. The concept of research and development didn’t mean anything to the studios; and it was like that all through the sixties and seventies. But even in that environment, a few small groups had the vision to use the computer for picture making. At that time, we thought a lot about what it would take to make the process economical and practical. It was at Lucasfilm that we laid out a plan for making computer graphics useful for the movies.” In a two-year period, the team solved fundamental problems regarding the complexity of film images, the need for realistic motion blur in combining CG and live-action, and the creation of photorealistic surface textures.



To appeal to adults as well as children, director John Lasseter included baby boomer favorites, such as Mr. Potato Head, in his cast of toy characters.



Another nostalgia-evoking character was Slinky Dog. In response to the current dinosaur craze, Lasseter and the writing team also developed a plastic T-rex character, played against type as an insecure neurotic.

The development team eventually broke away from Lucasfilm, and in 1986 regrouped to form Pixar. The new company soon developed rendering software, RenderMan, for which it won a scientific and technical achievement award from the Academy of Motion Picture Arts & Sciences. Within a few short years, RenderMan would be one of the most widely used software programs in the digital effects industry.

Subsequently, Pixar entered into a relationship with Walt Disney Studios, which was looking to reinvigorate its feature animation department. “At the time we were starting Pixar,” said Catmull, “Roy Disney’s vision was to revitalize the studio’s animation group by bringing in technology. We began working with them, and together we created CAPS.” A digital ink-and-paint system that employs a sophisticated multiplane camera within a digital environment, CAPS – Computer Assisted Production System – was awarded a technical Academy Award in 1992, shared by Pixar and Disney.

Outside of its relationship with Disney, Pixar produced computer animated commercials and short subjects. Directed by John Lasseter, a former Disney animator, *Luxo Jr.* – a 1986 short featuring two animated Luxo lamps – was nominated for an Academy Award. Two years later, *Tin Toy*, a story of how babies really treat their toys, won the coveted prize. *Tin Toy* would serve as inspiration for *Toy Story*. “I always thought there was a lot of potential in a story about toys that are alive,” Lasseter said. “We started to explore that idea in *Tin Toy* – but it really came together in *Toy Story*.”



All of the characters, sets, props and action were visualized initially in a series of hand-drawn storyboards produced by the Pixar art department. Art director Ralph Eggleston reviews a sequence of boards.

As innovative and fascinating as the technology in these shorts was, it was their deft storytelling that captivated audiences and caught Disney's attention. While Pixar's founders assumed that a half-hour television special was their next logical step, Disney's president of feature animation, Peter Schneider, convinced them to consider making the jump to a full-length feature. The studio and the animation company quickly entered into a three-picture deal; and that deal's first offspring was *Toy Story*, a charming tale of two toys – Woody, a pull-string cowboy, and Buzz Lightyear, a high-tech action figure – vying for dominance and the affection of a boy named Andy.

"From the beginning," remarked Lasseter, "what we wanted to do was a character film. No matter what kind of technology is used, no matter how a movie is made, the story is the most important thing. That's what makes entertainment; and that's what makes people come to see a movie. We looked at all the Disney animated films of recent years – but we realized we didn't want to do a musical. Then we looked at other genres; and we thought the 'buddy picture' was a good one to explore. We felt that had a lot of potential, because it really hasn't been done in an animated film. By its nature, a buddy picture gives you the opportunity to present tremendous growth in the characters. You take two characters who are absolute opposites, who don't like each other; then you put them in a situation where they have to learn to work together in order to achieve their goals. In the end, those characters are inseparable."

To strengthen their understanding of the genre, Pixar storytellers watched numerous live-action buddy pictures – movies such as *48 Hours*, *Thelma & Louise*, *Butch Cassidy and the Sundance Kid* and *Midnight Run*. "What we noticed about these films," said producer Ralph Guggenheim, "is that one character is really transformed by the experience, and the other is not. Ironically, it is the one who is



Directing animator Rich Quade and senior animator Peter Docter choreograph Woody's floppy movements using a similarly configured Fred Flintstone rag doll as reference. After working out basic body movement styles for each of the toy characters, the animators addressed facial animation and lip-syncing. Facile body movement and facial expressions – particularly for Woody and Buzz – were achieved by building computer models with an exceptionally large number of control points. A library of mouth poses provided the basis for lip-syncing.



Although many of the models were built from scratch in the computer, sculpted maquettes were digitized to create models for some of the key characters. Supervising technical director Bill Reeves refers to the original sculpture while viewing the Woody model on his monitor.

not transformed that we tend to remember the most. In *48 Hours*, we remember Eddie Murphy; in *Midnight Run*, Charles Grodin.”

Written by Joss Whedon, Andrew Stanton, Joel Cohen and Alex Sokolow, from an original story by John Lasseter, Pete Docter, Andrew Stanton and Joe Ranft, *Toy Story* opens on Andy’s birthday – a feared event among the toys, since birthdays and Christmas always mean new toys arriving to replace the old. Woody and his fellow toys quickly organize a reconnaissance mission to determine what toys may soon be invading Andy’s bedroom and discover that something new is indeed headed their way. Moments later, Andy and friends rush into the boy’s room, shoving Woody off his treasured spot at the head of the bed and replacing him with Buzz Lightyear. Named after famed astronaut Buzz Aldrin, Buzz boasts a Dudley Do-Right square jaw, retractable jet wings, fancy arm band laser and a ‘fresh out of the box’ attitude – convinced that he is on a mission to save the universe, the naive Buzz doesn’t even know he’s a toy.

To regain his position as Andy’s favorite toy, Woody attempts to knock the annoyingly earnest Buzz behind Andy’s desk – a place from which no toy ever returns – but, instead, accidentally bumps him out of the bedroom window. Branded a murderer by the other toys, an outcast Woody is forced on a quest to bring back Buzz – a journey that takes a bad turn when both characters are abducted by the evil neighbor boy, Sid, a well-known mutilator of toys. Trapped in the eerie confines of Sid’s room, the two refugees put aside their differences and team up to find a way out. Woody and Buzz manage to escape and make their way back home just as Andy’s relocating family pulls out of the driveway. A fantastic chase ensues as the two characters appropriate a remote-control car to catch up with their fellow toys packed inside a moving van. Now true buddies, Buzz and Woody reach their goal only after lighting the rocket that is strapped to Buzz’s back and using it to catapult them toward the speeding van.

The creation of *Toy Story*’s digital world and characters was a monumental task – not only creatively, but in sheer computer power. As opposed to the 100 gigabytes it took to create the dinosaurs for *Jurassic Park*, *Toy Story* generated 1000 gigabytes of data – and rendering the entire film took 800,000 machine hours. With the extraordinary number of elements that would have to be developed and processed, organization was a key concern in the early stages of production. To manage the project, Disney and Pixar brought in producer Bonnie Arnold. “The most difficult part of production,” remarked Arnold, “was when a single department would get hit with a huge volume of work all at one time. It was like moving a lima bean through a straw. We’d get lumps in certain places and have a frenzy of work. A lot of my job was making sure that we didn’t burn ourselves out over the four-year production. We had to know where to put our energies.”

The awesome assignment was also facilitated by a production and frame rendering management system – dubbed Ringmaster – developed by Pixar. “Ringmaster monitored all the computers in the building,” explained technical director Eben Ostby. “When a computer became idle, Ringmaster would look through its list of things to be done – at any one time there could be several thousand frames waiting to be processed – and pull a frame or group of frames to be assigned to that idle machine. Each frame took from ten minutes to twelve hours to render. When it was done, the machine put the finished frame back on one of our big disk servers to be taken to film and eventually archived on tape.” Although the system did need to be monitored, Ringmaster saved the production team countless hours of tedious render-wrangling.

Obviously, *Toy Story* was a tale requiring toys, toys and more toys. Both modern day toys and those dear to the hearts of baby boomers were included in the story. Falling into the latter category were an Etch-a-Sketch, a Magic 8-Ball, a Slinky Dog and Mr. Potato Head. “We wanted to create a sense of nostalgia for the adults in the audience,” said Lasseter. “We wanted them to be able to say: ‘Oh, I had that! Oh, look – a Barrel of Monkeys!’” To replicate the images of such trademarked products, Pixar had to first obtain clearances from the appropriate manufacturers – a difficult and sometimes frustrating process that inspired inside jokes concerning the number of hours Guggenheim spent on the phone with Mr. Potato Head’s lawyer.

Once specific toys had been chosen and cleared, the Pixar team concentrated on endowing each with a character and personality. “We looked at each of the toys, what they were made of, and tried to determine what their personalities might be as the result of their manufacturing,” said Lasseter. “For instance, Mr. Potato Head always has facial features falling off; and as a result, we thought he might have a chip on his shoulder. So we made him the rabble-rouser who stirs the pot and questions authority. Because of the popularity of *Jurassic Park*, we knew we had to have a dinosaur; so we looked at the T-rex toys out there and realized that even though a T-rex is supposed to be this fearsome creature, the toy T-rex would have a lot of problems. His forearms are so short, he can’t even scratch his nose; and most of the dinosaur models you see have pretty cheesy paint jobs. So we realized that the T-rex toy might be pretty insecure; and we decided to play him against type, making him this very nervous, insecure character.”

More thought was put into the characters of Woody and Buzz than any other. “In some respects,” explained Lasseter, “Woody and Buzz are opposites – and yet they have similarities, too. A cowboy represents a loner going off into the wild frontier. Buzz is the same, except his frontier is space. Woody



Early in the film, a birthday party for Andy prompts Woody and his cohorts to deploy miniature army men on a reconnaissance mission to bring back word of new additions to the toy chest.



To simulate the limited movement imposed by the plastic soldiers’ oval bases, directing animator Ash Brannon acts out a scene – wearing running shoes nailed to a board – as animator Rex Grignon sketches key poses.



is kind of an old-fashioned, drawstring type of toy. You can tell that he's been around for awhile – he's a bit worn. Buzz is all flash, the product of a huge marketing campaign for an imaginary TV show. It's easy to see how a kid would be dazzled by this new, sophisticated toy; and, as a result, he would tend to ignore his old favorite."

The toy soldiers are dwarfed by a balustrade as they lower a child's walkie-talkie through the railing for furtive communication with the troops below.

To make the movie as appealing to adults as to children, the decision was also made to give the toys intellectual senses of humor, as well as personalities and concerns that adults could relate to. "We decided that the toys approached their relationships with their child as a job," stated Lasseter. "When Andy leaves his room and the toys come to life, the room becomes their workplace. We started to think in terms of how a workplace is filled with different personalities – the company types, the middle managers, the yes-men, the brown-nosers, the people who question authority, the insecure people who know they're going to be laid off, and the career workers just waiting it out until retirement. There's also a lot boring stuff in the workplace – mundane things like staff meetings. When Andy's out of the room, it's like jury duty for the toys. They just sit and wait. So we have some shots where a couple of them are playing games like cards or Battleship or checkers."

While locking down the story and characterizations, Pixar and art director Ralph Eggleston were also engaged in creating a believable digital environment. "For anyone who has ever worked on a live-action set, our process would seem familiar," related visual effects supervisor Tom Porter. "Live-action has carpenters building sets out of wood. We go through the same process -- only with computer tools and without the raw materials." Early on, it was determined that the Toy Story environment would be highly stylized – a cross between live-action reality and a typical squash-and-stretch cartoon world. "We caricatured the sets," explained Eggleston. "The doorknobs are oversized and the doors are a little taller and thinner than they would be in reality."

"Our philosophy for the set indirectly came from Gary Rydstrom, our sound designer and an old friend," Lasseter elaborated. "He did the sound on all our short films and he taught me long ago that, in doing sound effects, if a ball bounces you don't just record the sound of a ball bouncing – because when the sound effect is cut in, it won't sound like it should. You have to make it bigger. To create the bark of a dog in Toy Story, Gary combined dog sounds with tiger sounds to make it bigger and more impressive. That's the philosophy we used in the look of the film. We went beyond reality, caricaturizing to make it more believable."

The digital sets were also enriched with a massive amount of detail. Much like the intricate artwork in a well-drawn comic book panel – where even backgrounds are handled in a meticulous fashion – each frame in Toy Story was filled to the edges with visual information. When the action takes Woody and Buzz into the parking lot of Pizza Planet, for example, it is filled with cars. "You don't notice the cars because you don't really focus on them," Lasseter commented, "but you'd notice it if the parking lot was empty. You see little highlights of one car, or a silhouette of another. Beyond that, you see a few lit windows off in the distance and maybe a black silhouette of a house."

The entire story was defined in hand-drawn storyboards that were then turned over to the digital modeling team which built a basic framework or skeleton for all of the characters, sets and props. "The first step in character modeling is creating the geometry," said supervising technical director

William Reeves. “The second is building in the controls that make it possible to animate the model. Controls enable the animator to raise a hand or move muscles in a character’s face.”

Since the model-building effort began before scenes and shots had been decisively nailed down, the modelers tended to overbuild, making educated estimates as to the angles from which their models would eventually be seen and building accordingly. Models for the lead characters were especially dense since they would be seen from virtually every camera angle imaginable. “For some of the models, we could cut corners,” said Ostby. “For instance, we didn’t always have to bevel the edges for every little piece of a building. But a character like Buzz, who was on screen a lot, had to be finished quite well. I thought I had met all the demands for the model – until about halfway through the film, when I got a call from the animation department saying that there was a hole up underneath his legs that needed to be filled. I thought, ‘How could they be seeing way up there?’ But sure enough, they could. In this film, you see Buzz from every possible angle.”

Similarly, the Woody model had about 159 controls built into the face alone. “We had to give the animators enough controls to provide them the ‘meat’ they needed to create believable performances,” stated Ostby. “Woody had to act in over seventy minutes of the movie.” The flexibility and range of the model was highlighted during a scene in the climactic chase in which the rocketing Woody and Buzz try to catch up with the moving van. In one shot, the camera catches Woody head-on, revealing the g-force effects on his skin – his cheeks are pulled tight, creating cartoony jowls.

While most models were built directly in the computer, some were digitized from sculpted maquettes. One model that was digitized was Scud, the evil Sid’s pit bull. Scud’s musculature seemed best served by a sculptor’s hand, so Shelley Daniels Lekuen – who built many of the models for Tim Burton’s *The Nightmare Before Christmas* – created a four-inch maquette. Adjustments to the shape of the dog’s snout, head and ears, and the proportionality of leg length to torso were made in a second life-sized version, which was subsequently digitized. “I spent a lot of my time just staring at Scud,” stated Ostby, “trying to figure out how I was going to fit surfaces so I wouldn’t get creases in the digital information. An example of this is the place where a leg and the torso meet. You can digitize the leg and the torso, but the spot where the two join together is going to take some refining. I spent about a week



Convinced he is an authentic champion of the universe, Buzz attempts to dazzle Woody with his wristband ray gun – actually a harmless red light bulb. Detailing on the characters included dirt on the edges of Woody’s clothing and a Disney copyright on Buzz’s backside.



Home to all the toys is Andy’s bedroom, one of many virtual environments created for the film. Stylized sets featured cartoonish characteristics such as oversized doorknobs and doors with funhouse-mirror-like distortions. Though somewhat caricatured, the sets were detailed with scuffed baseboards, wear and tear marks on

scratching my head over those kinds of problems, and about a day and a half digitizing one side of the model. Then I reflected that image in the computer and cleaned it up.”

the floor, and fingerprints on doors, all of which helped to create the illusion of a real, lived-in environment.

By far, the most difficult challenge for the modeling group was the building of the human characters. The Pixar team had gained some knowledge of the problems in creating such characters through its animated short film work. In *Tin Toy*, for example, the team had learned the difficulties of replicating human skin. “The baby in *Tin Toy* had muscles that were flexible,” related Bill Reeves, “but the skin wasn’t flabby like a real baby’s would be.” To avoid that problem, the characters in *Toy Story* were designed to be covered with as much clothing as possible to hide skin tissue. “That became a whole other problem, though, because we had to figure out how to make the clothing move and flow so that it wouldn’t look painted on.”

To enable the animators to create facial expressions, the human character faces were loaded with controls that could perform complicated actions such as lip curls. The most difficult part of the human anatomy to recreate was hair – a problem that has long vexed CG artisans. Several different methods were tested, including the layering of transparent, digitally painted surfaces. “The most successful experiment was based on modeling individual hairs,” stated Reeves. “Most of the kids were modeled with brush or crew cuts, which made the hair easier to deal with. With the short hairs in that kind of cut, we could do up to 35,000 individual pieces of geometry. The hairs were actually little cones applied with a shader that made them semitransparent and allowed them to change color from the base to the tip.”

Each completed character model was then moved to the layout department, where it was assembled with 3-D background sets and accompanying props. Basic blocking of a character’s actions was roughed out, along with camera movement. “We always found problems with that first jump from 2-D to 3-D,” said supervising layout artist Craig Good. “When artists draw storyboards, they do all sorts of cheats. There were several cases, for instance, where the storyboards showed Woody with his arm around Slinky Dog in a nice tight two-shot. In 3-D, that was a problem because of the disparity in the sizes of the two models. Woody is a little over a foot tall, and Slinky’s head would be down around his knees.”

Camera movement was also added in the layout department. Even though the digital camera was capable of fantastic gyrations impossible on a live-action set, the creative team opted for more realistic moves. “What bugs me – and most of us here – are the computer graphics camera moves that take you flying precipitously past huge marble columns,” stated Good. “The camera twists and rolls all over the place, until the whole audience wants to reach for an air-sickness bag. For *Toy Story*, we wanted something more like what you would see in a live-action film.”

In the computer, Good ‘built’ a crane camera that could be swiveled back across its own viewing plane. He also attempted to create a standard set of lens lengths for his artists to choose from. “A mistake a lot of people make in computer graphics is attempting to make something bigger in a frame by shoving the camera in real close. We tried to use the sort of perspective you would use on a live-action medium closeup, where you’d have a slight telephoto lens and then back up a little bit. It was more flattering to the characters.” Good and team also worked with the effects department to

enhance the live-action feel of the camera work. “The effects people added artifacts like lens flares in a couple of key places. There’s even a time-lapse that happens when Andy runs into his house and comes out in a different costume.”

In some cases, the camera movement and general staging of a scene represented a creative ‘drum solo’ for the layout team. One such case was the scene in which Buzz is knocked out of Andy’s window. In an homage to *Raiders of the Lost Ark*, the layout team recreated Indy’s famous opening escape from the temple. “We didn’t copy it shot by shot,” noted Good, “but our staging was similar and our camera even trucked in on Woody’s face – a move that Spielberg does to let the camera do the acting. There’s also a moment where *Indiana Jones* falls down on one knee. Ours is a little more cartoony: Buzz slips on some pencils and falls over.” The sound crew enhanced the parallels between the two scenes by using the actual boulder and dart sound effects from *Raiders* for shots of a huge rubber ball rolling toward Buzz and tacks raining down on the desktop from a jostled bulletin board.

Once a shot was composed, it moved on to the animation department. Animators hired for the production were chosen on the basis of their animating ability rather than their prior computer experience. The result was that most of them came from traditional clay, stop-motion or cel animation backgrounds, and thus required extensive training before they could work with ease in the digital world. “The jump from traditional animation to computer animation was a little strange at first,” admitted senior animator Peter Docter, “but I think everybody eventually realized that the thought process is more or less the same. You are still essentially an actor trying to communicate the character’s attitudes and emotions. John Lasseter worked very closely with Eben Ostby and Bill Reeves to create our animation system. It was really developed from the animator’s point of view, which was very helpful.”

Docter and his team began the animation process by listening to the character’s sound file – a recording of the voice actor’s dialogue. Tom Hanks and Tim Allen provided the voices of Woody and Buzz, respectively. The roster of voice talent for the supporting characters included Don Rickles as Mr. Potato Head, John Ratzenberger as Hamm and Annie Potts as Bo Peep. “We have a program that enables us to look at a sound wave and break it down into frames,” explained Docter. “I listened to the sound over and over again, then did an assessment of the pitch of the words.” That handwritten assessment divided each group of ideas into phrases or small thought progressions. Each progression, in turn, became the basis for a pose that Docter felt best illustrated that set of ideas. Sketching out high and low points in vocal tone, and matching those moments to a drawn key pose, Docter developed a template for his work on the computer. “What we try to do is get the body working first. We figure we can communicate most of the attitudes in mime, through the motion of the body.”

For movement reference, the animators reviewed videotapes of the voice-over actors. “Tom Hanks was a great help,” said Docter. “When he read his lines, even though he was standing in front of a microphone, he added lots of action. He had great facial expressions and little cool details that he put in his performance that we were able to use.” The animators also gained inspiration from the toys themselves. “We thought about what each character was made of in determining how he would move. We made a Woody doll out of spare parts of other toys and studied how a floppy rag

doll actually moves. We tried to put a lot of that into Woody; whereas Buzz is like a GI Joe – more tight and efficient with his movements.”



Meticulous attention to detail also extended to backgrounds. At Pizza Planet – discovered by the quarreling Buzz and Woody after they tumble from the family car and are left behind – a nighttime exterior shot reveals the futuristic diner and game arcade, with a parking lot full of cars, and a background of distant lights and silhouetted buildings.



Inside Pizza Planet, Woody tries to rescue a deluded Buzz – who believes the green space alien toys in the Claw arcade game are his avid followers.

Only after the body movements had been determined did the animators turn their attention to the facial expressions and lip-syncing. “After doing the body animation,” noted Docter, “we placed the head on the model and began to work with the facial controls.” In developing the facial expressions, Docter and crew challenged preconceived notions of what an animated character was capable of expressing. Traditionally, fast-paced animation has not afforded the luxury of time for a character to ‘think’ on camera. For *Toy Story*, the animation team determined that the characters were strong enough to hold an audience’s attention, even when they were not moving or speaking. “If we’ve done our job right, the audience’s eyes will go right to the character’s eyes – which is what happens in real life. Mark Oftedal did a shot where Woody is thinking, his eyes darting from side to side. That was groundbreaking for us. Suddenly, you could see the gears in his head turning. In that shot, Woody really jumped off the screen as a character, instead of just a bunch of numbers or geometry. We wound up repeating that kind of expression throughout the film.” Lip-syncing was facilitated by a library of mouth poses that could be used to form various sounds. “That technique got us about eighty percent of the way there. Then we would refine the mouth movement to tailor it more exactly to a particular sound.”

Throughout the animation process, the animators had to consider the surrounding environment into which the characters would be placed. Since nothing in the CG realm has any solidity unless it is programmed in, the animators had to create synthetic inertia and gravitational pull for their characters as they interacted with the sets and with each other. “We had to mime contact,” said Docter. “For instance, if a body is in motion and it stops abruptly, that creates the illusion of hitting a hard surface. Initially, we also had to eyeball, frame by frame, the lock-down of the characters’ feet. Later on, the models were built to do that automatically.”

Working in tandem with modeling, layout and animation, the shader department created textures to be applied to every character, prop and set. Unique surfaces had to be applied to some four thousand objects; and an entire library of textures had to be created to distress or age surfaces in a seemingly infinite number of combinations. “Our digital artists painted a dozen divots, six watermarks, six drips, patches of dirt, moss, rust, scrapes, scratches and smudges that we used as templates to scatter throughout the sets,” said Tom Porter.

Layers of dirt and other texture details were built up in channels within RenderMan shaders. Woody had one of the most complex channel systems. Besides the red, green and blue channels that provided his colorization, the cowboy hero had a specular channel to control the way in which his



*Employing an age-old animation technique, Pete Docter makes faces in a mirror and sketches the resulting reflections. Hired for animation ability rather than computer competency, nearly all the animators on *Toy Story* came from traditional cel or puppet animation backgrounds.*

various surfaces reacted to light, a displacement channel to add creases, pore marks or scratches, a dirt channel and a channel used only at the film's end – a lipstick channel to provide a display of red lip marks on Woody's face after he has been kissed by Bo Peep. "All of the little details on Woody would have been impossible to do with cel animation," observed Lasseter. "He had piping on his clothes, and cowhide and a checkered shirt with little pearl buttons. His jeans are worn out, and there's dirt on the edges of his clothing." Brand-new Buzz was endowed with his own flashy detail. "Buzz had all the appropriate decals, and a Disney copyright on his butt – a detail I remembered about my old *GI Joes*, which had copyrights stamped on their butts. Those are the kinds of details you can get in this three-dimensional medium."

As with every other department in the production process, the shader team was concerned primarily with supporting the through-line of the story. To that end, Tom Porter and his crew worked closely with Eggleston in applying the finishing textures to the movie's stylized sets. "Ralph and I had offices next door to each other," said Porter, "so I'd walk in and ask: 'How do we handle the rooms?' And he'd say something like: 'Well, Andy's family has been living there for fifteen years. There are a few divots, some smears, some chalk marks on the baseboards. There are probably some fingerprints on sides of doors. But in Sid's room, crank it up by a factor of three, because here we've got a guy who probably has a knife and will be gouging marks in tables and chipping away at things. Of course, he leaves the window in his room open all the time, so everything near it is weather-beaten.'"

To aid the shader department and keep them in line with art department concepts, Eggleston provided hand-drawn sketches, written instructions, cutouts from catalogs and other photographic reference materials. For a scene in which Woody and Buzz stand under a greasy, mud-caked diesel truck, the shader team was provided with photographs Eggleston shot by crawling beneath a truck parked outside the Pixar offices.

One of the most challenging aspects of the production for the shader department was creating a believable skin for the human characters – an ongoing problem in computer graphics. "There are really two layers to our skin," explained Porter. "The epidermal layer on top and, underneath, a layer through which blood flows. There's a filmy oiliness on top that adds extra reflectivity. There are freckles on the outer layer and some blushing that happens on the inner layer. In the end, our art department painted ten textures to try to capture all of the characteristics of skin – the freckling, the wrinkling, et cetera. The most difficult areas were where the skin met the hair line, or where it became translucent, like around the earlobes."

Lighting was the next step. For each shot, a master lighting design was created to set the dominant light sources. "Pixar never really paid a lot of attention to lighting before this production," said lighting supervisor Galyn Susman, "so we didn't have any tools. We had to create our own as we went along. If we had to fake a shadow, we'd ask Ronen Barzel, our computer wiz, to write something. He was our 'write-it-in-thirty-seconds' guy. He basically created an entire library of tools for us during the course of production."

Lighting was approached much like a live-action shoot – but without the physical hassles and constraints. A digital light did not necessarily have to be placed inside a room to illuminate a scene; it could be 'hung' in virtual space somewhere outside. Lighting colors and shadows were only a

mouse click away. More challenging were lighting effects such as bounce light and backlighting. “Bounce light had to be simulated,” said Susman. “After I determined the dominant light in a shot, I’d look around to see what else was in the scene. If there was a red floor, then I’d have to manually put in another red light that bounced or reflected the light the way you would expect to see it. What makes backlighting work in live-action is its amorphous property. My hair, for example, might pick up a lot of light and give off a sheen that would highlight me and separate me from the background – but there is no such property in the computer. You can’t just throw a light behind somebody and let nature do its magic. You have to swing the lights around and pull more from the sides.”



Trapped in the bedroom of sadistic Sid – whose penchant for mutilating toys has resulted in a collection of mutants – Woody and Buzz recoil in fear from a sample of the boy’s handiwork. To set an ominous mood, the lighting in the room was stark, supposedly emanating from a single, unshaded light bulb. Both in lighting and camera movement, the Pixar team attempted to replicate live-action moviemaking style.



Sid experiments on the hapless Woody. In creating the human characters, digital artists grappled with the vexing problem of replicating skin and hair. Textures applied in multiple layers were used to simulate realistic skin characteristics such as freckling and wrinkles.

Besides providing illumination, the lighting also helped to create a stylized mood. One such use was for the scene in which Woody knocks Buzz out of Andy's window. "If you look at the shot," explained lighting co-supervisor Sharon Calahan, "the orange light on Woody's face starts out on his left and then sweeps around, implying that there's sun on his left and the cool blue of sunset on his right. There's nothing real about that, of course – we just did it that way to heighten the drama." Stylized lighting is also in evidence when Woody and Buzz are trapped in Sid's room. "Everything is gray, almost monochromatic, to suggest the characters have reached their ultimate low points in the movie."



While crew-cut hairstyles were employed as much as possible to simplify the rendering process, characters such as Sid's sister sported long hair. Individual pieces of geometry were replicated to create thousands of hairs on the human characters' heads.

While the progression from modeling to layout to animation to shading and, finally, to lighting was the norm, not every shot in the movie moved down the production pipeline in perfect succession. Some elements, such as those considered special effects, took their own course. "The whole operation at Pixar is really about character animation," said Porter. "To us, effects are those things that are out of the mainstream of standard character animation – things such as a rainstorm or clouds swirling in the sky."

In an homage to *In Cold Blood*, Woody and Buzz, in Sid's room, have nearly given up hope of escaping. It is dawn and rain is falling, forming drops that glide down Sid's dirty window and leave thin moody shadows on the faces of the toys. "In several shots," Porter explained, "the rain streaking down the window provides a kind of reflective view that you can see in Buzz's helmet. To create this, we built a small number of animated textures of drops falling down the window. The art department gave us the basic tracks of four drops; then I wrote a program that allowed a drop to start at any particular frame and be placed at any spot on the window. We timed how the drop came down, how it moved back and forth and then disappeared in a ghostly fashion."

To gather reference for the effect, on more than one occasion Porter sent an assistant outside to hose down his window. From inside his office, Porter – together with Lasseter and the effects team – observed the effect of the water on glass, determining which types of water drops were the most dramatically appealing. "We discovered that if the window was too dirty, the droplets turned to a wash; but if the window was too clean the drops only beaded up. The best effect came from a happy medium between the two – so we used a slightly dirty window as the backdrop for the scene. Each drop moved down the glass and disappeared after about fifteen frames. We had to monitor the rainstorm itself – as the scene progresses the storm goes from heavy to medium to light to clearing off. At that point, there are beads, but no water droplets, on the window."

A more obvious effects scene is one in which a rocket blast propels Woody and Buzz toward the departing moving van. The scene opens with a stark white frame that accentuates the initial explosion. "From there," related Porter, "the image is made up of a couple of particle systems and some hand-painted elements. Basically, the fireball is built up from multiple particles being shot

out. There are also more obvious individual particles at the edge of the fireball that were built in a particle system.” A contrail for the rocket was produced by Oren Jacob, who created a hundred or so smoke elements that could be individually manipulated.

Toy Story’s most challenging sequence, both artistically and technologically, was the climactic chase scene, comprised of 243 shots and covering the virtual world equivalent of two miles of roadway. To simplify the process of visualizing the action and creating it digitally, Lasseter and storyboard artist Andrew Stanton limited the chase to a straight piece of road, broken only by what the artist’s dubbed ‘The Slinky Curve’ – a series of shots in which one half of the Slinky Dog is thrown out to save Woody and Buzz in the remote-control car. In the sequence, Slinky stretches out as the moving van rounds a curve. Holding on to the stretched-out toy, Woody and Buzz maneuver like water-skiers in the invisible wake of the van, coming dangerously close to cars parked along the roadway.

To develop the ground plan for the chase, Stanton locked himself away for two weeks and roughed out a series of storyboards. “I spent a lot of time watching chase sequences,” said Stanton. “I edited together the chariot race from *Ben-Hur*, the hill chase in *Bullitt*, the train sequence in *Back to the Future III*, the scene in *Raiders of the Lost Ark* where Indy is on horseback, and the scene where the car is driving the wrong way down the freeway in *To Live and Die in L.A.* I watched them over and over again to get an idea of how the intensity in those chases was created. Since ours was a linear chase, it ended up most like the scene in *Back to the Future III*.” After Stanton finished his storyboard, an animatic was created by editor Lee Unkrich who digitized all the boards and took them into the Avid editing system. “After I finished my work and passed it on to Lee, he finessed it even more. He took a lot of fat out of some of the shots and clarified the camera angles.”

The next step was to build a background set for the chase – neighborhood houses and street intersections – that was varied and realistic enough to be believable, yet not so detailed that it would drain too much on the company’s computing resources. A system was devised that enabled the digital team to create and arrange a few set pieces to look like more. “It was almost like a giant Lego set,” said Lasseter. “We created twelve houses that had very simple geometry – a flat fifties-style house, a Tudor-style house and so on. Then we created about twenty lots with different landscaping and driveways. They all became interchangeable pieces of a puzzle.” To keep the size of the computer files down, the team used an expressionistic approach to detail. A tree in the foreground might have literally thousands of leaves; but a tree in the background would be represented by a sort of snapshot image. Often, the images were layered to create the impression of depth.

In the fall of 1995, Lasseter, Guggenheim, Arnold and the creative teams at Pixar and Disney completed Toy Story. The size and groundbreaking aspects of the project could have made it a grueling experience; but, remarkably, the four-year process was as satisfying as the final product. “Working on this movie was as much fun as watching it,” commented Andrew Stanton. “I knew, going in to work each day, that I would be guaranteed a laugh. We all wore a lot of hats, relying on each other creatively for



inspiration. I think that – and John’s directing style – were directly related to how much fun we had on this movie.”

“We really tried to give the animators the best film to work on, and the best experience possible,”

Lasseter confirmed. “We knew they were going to be working really hard, so we wanted it to be on

something that was worthwhile and fun. It didn’t have to be a traumatic experience to make this movie – and it wasn’t. Everybody loved it.”

When Toy Story opened, it promptly became one of the big hits of the holiday season, well worth all of the time, effort and expense that had gone into its making. The movie was not only the first fully computer animated feature, it was also a hilarious, charming adventure appreciated by movie-goers of all ages. “You look at any aspect of this movie, and it is a milestone,” said Lasseter. “It is the first computer animated film. It has 1561 shots. It is 77 minutes long. It has thirty characters. The quality of the animation is the best that has ever been done. Technologically, it is a huge achievement. But the thing that I am most proud of is its strong story and characters. The animation was the groundbreaking thing about this movie; but our intention was for audiences to get so caught up in the story and characters that they would forget the animation – and I think they do.”

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ON THE WATER FRONT

article by Jeff Odien

The time is 500 years in the future. The ozone layer has been depleted. The polar ice caps have melted. The remnants of humanity – adrift in a hostile ocean environment, living aboard giant floating atolls patched together out of the debris of long abandoned ships – are pitted against one another in a brutal struggle for survival.

At the center of this struggle is Enola (Tina Majorino), a young girl with a mysterious tattoo on her back – purported to be a map to Dryland, the mythic refuge from the omnipresent water. Reluctantly, the Mariner (Kevin Costner), a survivalist who trawls the ocean floor for barter-worthy treasure, takes Enola and her guardian, Helen (Jeanne Tripplehorn), aboard his high-speed trimaran, helping them to dodge the evil Deacon (Dennis Hopper) and his band of renegade ‘smokers.’ A quintessential loner, the Mariner gradually learns to care for his two charges. When the Deacon captures Enola and takes her to his base on a derelict oil tanker, the ‘Deez, the Mariner rescues the child, destroys the smokers, and with a small band of atoll survivors, finds the way to Dryland.

The epic proportions of the Universal release – directed by Kevin Reynolds and produced by Kevin Costner, John Davis and Charles Gordon – were nearly matched in scale by the media furor that surrounded the production. Due in part to the unpredictable nature of its ocean setting, the film achieved a new record in production costs – \$175 million – and its hemorrhaging budget was widely reported by the press. Adding to the din were the dire predictions of naysaying insiders, heatedly countered by the hyperbole and grandiose promises of studio press releases. The hoopla was hardly the kind of attention Universal publicists dreamed of;

image



Much of Waterworld – a Kevin Reynolds film about life on future earth after a watery holocaust – takes place aboard a trimaran belonging to a mysterious loner, the Mariner. Two trimarans – one for shots of the craft in trawling

but it served to heighten anticipation of the movie's opening.

When *Waterworld* was finally unveiled, it proved to be neither the smash hit that might have justified its exorbitant budget, nor the disaster many predicted.

Endowed with a solid cast, beautifully executed

production design and striking visual effects to bolster its futuristic story, the ambitious *Waterworld* was an escapist summer entertainment that brought in respectable receipts at the boxoffice.

Originally conceived ten years ago, in a script written by Peter Rader – later revised by David Twohy – *Waterworld* was finally catapulted into production when Reynolds, Costner and Gordon took on stewardship of the project. The production team assembled by the trio included a number of Academy Award winners, including director of photography Dean Semler, production designer Dennis Gassner and visual effects supervisor Micheal J. McAlister. Lending vigorous support were physical effects designer Peter M. Chesney, special effects coordinator Martin Bresin, underwater cinematographer Pete Romano – and Stetson Visual Services, in its swan song as a company. Although a variety of effects facilities would ultimately contribute, Cinesite was charged with producing the majority of *Waterworld*'s digital effects and composites, while Rhythm & Hues and Boss Film Studios provided computer generated imagery for a couple of key scenes. Visual effects producer Kimberly Nelson was largely responsible for wrangling the huge workload through the various facilities and ensuring that shots were completed in a timely manner.

Gassner, Chesney and McAlister had worked together previously on *The Hudsucker Proxy*, and it was Gassner who first solicited McAlister's involvement. "I didn't commit right away when Dennis first talked to me about *Waterworld* in September 1993," McAlister recalled. "I was just completing *Demolition Man*, and I wanted some time off. I was also a little reluctant, just because of the size of this project and the time commitment it would require."

Outweighing McAlister's reservations was the prospect of taking on effects challenges inherent in a movie shot entirely on water. "*Waterworld* gave me the chance to do a few things that had never been accomplished before," McAlister stated. "One of the biggest challenges was the dive sequence, where the Mariner takes Helen down to the city of Denver, which has been totally submerged underwater. To take two people 400 to 600 feet underwater and explore this abandoned city was a huge undertaking, logistically and technically.

"The other sequence that was interesting to me was the sinking of the 'Deez at the end of the movie. Until computers, the idea of water interaction with miniatures was a scary one. This was the first time, since all of that digital power had been in existence, a show had come around that would actually allow us to freely address the issues of water scaled to miniatures. I was looking forward to finding out what the new limits might be." Intrigued by its trailblazing possibilities, McAlister finally accepted the *Waterworld* assignment in March 1994.

Like everyone who joined the production, however, McAlister could not have imagined the ultimate magnitude of the project. Originally slated to have 120 visual effects shots, *Waterworld*'s ever-expanding scope mandated an additional sixty by the time principal photography wrapped in Hawaii in January 1995. That total more than doubled between January and the end of March, when

mode and another for high-speed sailing sequences – were built by Jeannette North America and engineered by physical effects veteran Peter Chesney. Swankworld atoll – the largest set in movie history – was built in sections, then assembled and positioned in harbor waters off The Island of Hawaii.

a first preview was screened for test audiences. Not only did the shot count rise exponentially, the postproduction schedule for the completion of those shots was cut from a tight six months to a nearly impossible four. In a last-minute scramble, shots were farmed out to no fewer than thirteen effects facilities, all of which worked against crunching deadlines to finish the final count of 340 visual effects shots before the film's already delayed release.

The frenzy and frustration that would characterize production's end were not foreshadowed at the beginning, when conceptual artist Steve Burg – one of the first people to join the project – and production illustrator Stefan Dechant sat quietly for months in a trailer at Universal rendering drawings and paintings of various boat and atoll designs. As the central set piece of the film, the atoll required months of careful consideration before undergoing a monumentally difficult construction on location in Kawaihae, Hawaii.

To arrive at concepts for the atoll, Burg imagined himself in the place of a desperate people who had survived for centuries and attempted to create a haven built from the limited materials available to them. The result was a functional, yet fantastical circular fortress built upon a foundation of boats. “The circular fort idea made sense, in terms of the story,” Burg stated. “It had a gate, a central area, and it was protective, like a castle.” The atoll was also designed to reflect the survivors' spartan and archaic existence. Rather than gas or electric motors, equipment such as the atoll's massive gate was dressed to look as if it were powered by a system of gears and counterweights made from bags full of sea water – the only substance in plentiful supply in *Waterworld*.

A flotation test model, eleven feet in diameter, was fabricated by Lockheed for Peter Chesney, who would be charged with ensuring that the full-scale set designed and built by Dennis Gassner would actually float and maintain its integrity when put into the harbor waters in Hawaii, and beyond. “We floated the model in a wave tank to look for problems in the atoll structures,” said Chesney. “This was a tank in San Diego where they test oil tanker and other ship models.”

While tests were being conducted and designs finalized, the atoll was already undergoing construction in Hawaii – a jump-start mandated by the nearing principal photography schedule. “We condensed what should have been a year-long



Long before the start of principal photography, illustrator Steve Burg spent months rendering drawings and paintings to conceptualize key sets and action sequences. The design of the Mariner's vessel was one of the production's earliest concerns. After studying reference materials, Burg conceived a variety of trimaran designs that were somewhat futuristic, yet suggested the survivalist mentality of the Mariner. One of his early paintings drew inspiration from movie spaceships.



Burg also produced concept illustrations for the deep dive – a sequence in which the Mariner leads Helen to the ocean floor where the abandoned city of Denver lies. The

project into three months,” noted Chesney, “building the atoll while we were designing it. In that way, it was – as Dennis was fond of saying – a ‘sculpture in progress.’” As designed, the atoll was comprised of eight modules, averaging eighty tons apiece. To meet the schedule, the crew had to build one module per week – a backbreaking pace sustained by a crew of five hundred working around the clock.

central image of the scene was a nuclear submarine lodged amongst long-submerged buildings.

Construction would have been daunting enough if the atoll were only a set; but, since the plan was to tow the giant construct out into open ocean waters at some point in production, it also had to be seaworthy. “Once we took the atoll away from the dock and put people on it,” Chesney observed, “it was no longer a set – it was a vessel of some classification. It had to meet those kinds of requirements. I wasn’t about to let this production turn into some kind of maritime disaster.”

Flotation units – engineered and designed in partnership with Lockheed – were positioned in the harbor to support the atoll set. Each flotation unit carried a specific atoll module conceived to function as its own entity within the structure as a whole. Among the more dominant structures were the gate, the Organo Barge – dominated by a huge tree surrounded by a gooey sludge into which all deceased atollers are ‘recycled’ – and the tower where the eccentric Gregor (Michael Jeter) tinkers on a variety of inventions, including a hot air balloon.

A three-point system of joints was devised to connect one flotation unit to the next. “The atoll was built as a space-frame structure,” Chesney explained, “like a geodesic dome, with point-to-point interconnection. To give the whole thing some movement and give, we used pivots in the outer joints. We wanted this thing to look alive on the water.” Decking throughout the atoll was made from lightweight steel grating so that it would not collect water. “One of the crucial design considerations was that the majority of the atoll’s decking was only two and a half feet above the ocean surface. A single four-foot wave could add tens of thousands of pounds of weight to the unit. Because of the weight factor, we had to choose the most lightweight grating we could find. That meant constant repairs – but we couldn’t afford to add any more weight to the atoll than absolutely necessary.”

So delicate was the balance between weight and flotation, every time a unit was modified – even minimally – its adjusted weight had to be factored in, and more flotation had to be added or moved to ensure that the unit would remain stable under worst case projections of wind, waves or people crowding one side. “We had to confirm the weight of every single nut and bolt. There was no room for error.” Throughout production, a strict flotation management program was maintained. “We relied on specific data calculations every day. We would factor each unit’s current waterline buoyancy mark, the wind maximums and the sea conditions. A laptop computer crunched those calculations and told us the maximum allowable crew and actors that we could have on any one unit.”

The atoll sections were positioned atop the flotation units, one at a time, by 100-ton cranes. For the big gate unit, the pair of off-load cranes was insufficient, so production procured a 250-ton floating crane, the largest in Hawaii, which was used in conjunction with the smaller cranes to lift the set. Once the atoll was assembled in the harbor, it was anchored through a four-point, cross-shaped mooring system devised by Chesney and Mark Keane. “We used two ten-ton navy anchors and two

30,000-pound Danforth anchors, connected at the center with a half-mile of two-inch chain that itself weighed fifty tons.” Complicating the mooring system was the fact that the atoll would be rotated several times during production. Because of the harbor’s proximity to land, it provided only 170 degrees of clear horizon. Beyond that were views of gantries and volcanoes. “The atoll was supposed to be in the middle of an endless ocean,” said Chesney. “To create that illusion, we had to spin the set to make sure that whatever part of the atoll we were shooting, we would still have a clear horizon. This central-point mooring enabled us to spin the atoll quickly, with little horsepower. A couple of 200-horsepower outboards would turn the thing in an hour.” When completed, the 365-foot-wide expanse of floating metal and debris – with one full acre of deck area – was the largest free-floating articulated structure ever built.

The atoll is first revealed as the Mariner enters its gates on his trimaran to trade with the atollers. A focal point for much of the film’s action, the trimaran was as important an element of the show as the atoll; and Steve Burg devoted much of his early illustration efforts to its design. “I knew nothing about boats,” Burg confessed, “except that they float. So my first job was to educate myself. I went to a bookstore and brought home a pile of books and magazines with pictures of sailboats. I also started to phone shipbuilding companies for information.”

One of the companies that responded to Burg’s inquiries was Jeanneau, North America – one of the biggest boat manufacturers in the world – which provided a videotape featuring a trimaran, a cousin to the catamaran. The remarkably fast and elegant boat was a far cry from the garbage barge the initial script had described as the Mariner’s vessel. “The producers wanted the Mariner’s boat to be special,” Burg noted, “and they didn’t want him to be on a scow. After we saw the videotape from Jeanneau, the trimaran became the boat of choice.”

“Trimarans are an exotic form of single-hand racing sailboats,” explained Peter Chesney, who would be responsible for engineering the Jeanneau-built vessel to meet the story’s demands, “and they are incredibly fast. Dennis Gassner and I went for a ride on one – in an 18-knot wind we were doing 24 knots. It felt as if we were on a machine, not a boat.”

Because of its configuration – a center hull with two wide outriggers – the trimaran was also exceptionally stable. “I learned that you can stress a trimaran to very high speeds without danger of tipping it over,” Burg related. “It also has a large deck area, which was something else the producers wanted. For all these reasons, the trimaran looked like a winner. I began designing unusual versions of the boat, giving it a futuristic, clean shape – basically, a spaceship for the water.” Burg also endowed the trimaran designs with artifacts suggesting the survivalist mode of its owner. “I was asked to push the ‘Swiss Family Robinson’ motif to its maximum. I came up with drawings in which you could barely see the boat. It was covered with trees, a house, canopies, cranes, a lookout post, and the urine-purifying machine featured at the beginning of the movie.”

The most striking characteristic of the Mariner’s trimaran, as envisioned by the filmmakers, was its transformational capabilities, first revealed in the movie’s opening sequence. Leaving his boat unattended while he dives for booty, the Mariner emerges to find that a drifter has stolen his precious lime tree and that a band of smokers is heading his way. To retrieve his flora and escape the smokers, he engages an ingenious system of counterweights and gears to quickly transform the trimaran from trawler to high-speed racer. As the Mariner rotates the arms of an old motorcycle

gear mechanism, sails are cranked up, eggbeater rotors in the middle of the boat cease spinning, a telescoping boom lifts out of the deck, and the mast extends from fifty-five to eighty-five feet in height.

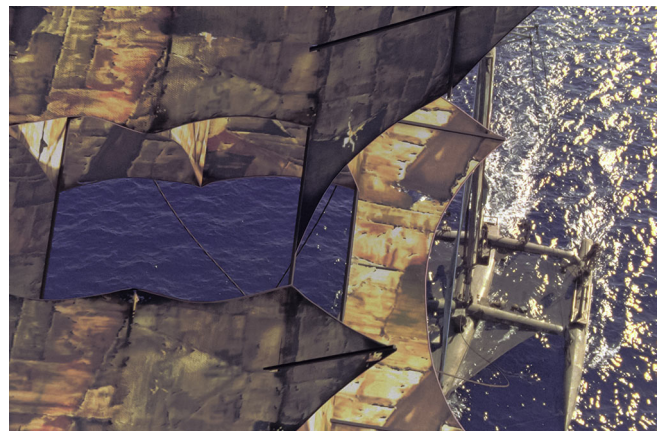
The trimaran's transformation was such a crucial element of the story that Dennis Gassner engaged Stefan Dechant to illustrate it in a series of animatics. "Dennis thought the trimaran needed something to make it unmistakably the hero's boat," observed Dechant. "When the transformation idea first came up, Steve Burg did five quick sketches of the boat showing different stages of it. It was my job to animate those images into one continuous sequence of events." Utilizing a NewTek Video Toaster, Dechant constructed a 3-D rendering of the trimaran. "We kept it pretty rough to allow for future design changes. Steve and I worked out how all these pieces would fold into the boat and how they would come out. We were really trying to show the timing of this transformation – how each part would come out, bam, just like that. The animatics weren't intended to work out the engineering, but to illustrate the aesthetic sense of the transformation."

As they worked on the animatics, both Dechant and Burg assumed that the trimaran transformation would be achieved as either a miniature or a computer generated effect. "It never occurred to us that they would actually try to build it for real," Dechant commented. But building it for real was precisely what the producers intended – an engineering task handed over to Peter Chesney and his crew. Chesney worked closely with Jeanneau chief designer Bruno Belmont in designing two trimarans – one to represent the boat in trawling mode that was used specifically for the transformation sequences, and a duplicate for performance sailing.

Although the transformation was made to look as if it were powered only with counterweights and wind, and initiated by the Mariner alone, in reality, it was a complex engineering feat requiring hydraulic pumps and winches – custom built to fit into the boat's limited space – and the efforts of a crew of four, operating from cramped quarters within the hull. "We used hydraulic accumulators to help power the boat's actions," explained Chesney. "The accumulators stored pre-pressurized hydraulic oil to use for a surge of energy. That powered the boom lifting out of the deck, the subsequent extension of the boom and the lifting of the mast. The boom was approximately thirty feet long, but it had to fit into a nine-foot space below deck. We built a well into the



Another early concept was the whalefin, featured in a scene in which the Mariner is swallowed by a giant hammerhead fish with gaping jaws that open sideways. Rhythm & Hues computer generated the whalefin, which was subsequently intercut with live-action footage of actor Kevin Costner being dragged behind the trimaran. Interactive digital effects created the illusion of the creature's moving through the water and breaking its surface.



hull of the boat during construction to fit this telescoping boom.”

The four-man crew – two line handlers, captain and navigator – were responsible for sailing the vessel, aided by a video system hidden in the rigging of the boat. “We had five monitors and an electric joystick controlling the rudder down below,” Chesney said.

“The boat was equipped with a fifty-horsepower diesel engine. Figuring out where to put all this stuff, along with space for the crew, was a big design challenge in itself.”

After outrunning the smokers and overrunning the drifter, the Mariner continues sailing toward the atoll, where he trades a precious jar of dirt for supplies. Preparing to leave the atoll, the Mariner is detained when it is discovered that he is a mutant – one of a rare breed that has adapted to the ocean environment with the development of webbed feet and gills tucked behind the ears. The gills – prosthetic appliances built by The Burman Studio – would be featured in several shots. While the prosthetics sufficed for most of those shots, the initial reveal of the gills required digital touch-up in postproduction, due to their unintended resemblance to female genitalia. “In that first shot, the gills looked bright red and kind of rude,” McAlister commented. “The producers were afraid the audience would snicker; so we were asked to fix it.” A digital paint job at Cinesite – overseen by senior digital effects supervisor Brad Kuehn and digital effects supervisor Jamie Price – served to make the offending gills less so by changing their shape slightly and desaturating their bright red color.

Although designed and built as a nonarticulated appliance, the gill prosthetic was made to appear as if it were pulsating in a later underwater scene in which the Mariner breathes for Helen as they hide from the Deacon and his smokers. To realize the pulsating effect, footage of the initial shot of the gills was added to the underwater photography, which was filmed in a tank. “We started with the first shot of the gills, just as the atoller peels it open behind the Mariner’s ear,” McAlister explained. “We took that opening motion and rock-and-rolled it so that the gill would open and close repeatedly, making it look as if water was being pushed through it. Then we motion-tracked it onto the back of Costner’s head, blending it with a wonderful paint job. That was all done by Alex Frisch on a Flame at 525 Post Production.”

Digital paint tools were also employed to touch up the webbed feet appliances worn by Costner in a limited number of shots. “All Kevin had to do was walk a few steps,” McAlister noted, “and the webbed prosthetics on his feet would be destroyed. By the time take two or three came along, the damage was clearly visible. So we went in with digital paint tools and polished out the wrinkles, tears, rips and the general funkiness of the webbed feet.”

With the discovery of his gills, the Mariner is imprisoned in a cage on the Organo Barge. Ironically, his chance for freedom comes when the atoll is attacked by the smokers, who arrive by boat, water skis and souped-up Jet Skis to destroy the atoll and find Enola. The large-scale spectacle – featuring ski-jumps over the atoll walls and underwater Jet Ski maneuvering – was realized, in part, by special effects coordinator Marty Bresin and his crew. “We completely overhauled six Jet Skis for the underwater shots,” said Bresin. “We aged them, took the motors out, and put vents and tanks in

Rhythm & Hues was also charged with creating a computer generated spinnaker kite for a scene in which the Mariner evades the smokers by spurring the trimaran into high-speed mode. To help the digital team envision and animate the kite’s unfurling action, renowned kite maker Tom McAlister – brother of visual effects supervisor Micheal McAlister – built a small reference model out of balsa wood and paper.

them that allowed air to come out of scuba tanks and into the carburetors. That air was then released as exhaust. We rigged these Jet Skis so that they would actually run for up to thirty seconds underwater.”

Bresin was also instrumental in achieving shots of four smokers on water skis being towed by an airplane toward floating ramps that propel them over the atoll walls. Initially, the plan was to have the skiers towed by the real plane; but it was soon discovered that the craft did not possess sufficient power to accomplish the task. The alternative was to position the airplane compositionally where Reynolds wanted it in the scene and have the skiers towed by a helicopter, piloted by aerial coordinator Craig Hosking. Bresin’s team attached ski ropes to a 500-pound lead ball that hung 125 feet beneath the airborne helicopter. Cable lines then ran from the ball to the Jet Skis. “As the helicopter flew forward,” explained Bresin, “the lead ball would hold the ropes taut.”

Both the helicopter and the lead ball and lines had to be removed digitally from the resulting footage, creating a big cleanup job for Cinesite. “If we’d had a helicopter against a bald, blue sky,” noted Brad Kuehn, “we could have just cut a hole around the helicopter, taken it out, and filled the hole with blue sky cloned from the sky around it. In this case, though, we were handed a cluttered sky, with smoke and wires that weren’t in the proper perspective. It really took an artist’s touch to remove the helicopter and all the smoke and wires without any telltale signs. Even with all these wonderful digital tools, it still comes down to the artist’s ability.” After the cleanup was completed, Cinesite inserted CG cables stretching from the skiers to the airplane using a proprietary software called Movie Tracker.

In the midst of the chaotic attack, Helen and Enola run to *Gregor*’s tower to escape in their friend’s hot air balloon. In a moment reminiscent of *The Wizard of Oz*, the balloon accidentally drifts away, with the inventor on board, leaving the two behind. While a practical gondola was used to film live-action scenes between the actors, wide shots of the balloon in flight were achieved by Boss Film Studios. “Any time you saw the balloon from a distance,” said McAlister, “that was all Boss’ CG work – the gondola, the people in the gondola, all the cables and the balloon itself.”

At Boss, digital effects supervisor Sean Phillips digitized a foam model of the balloon, provided by the production, then used Wavefront software to animate appropriate ripples and undulations in the computer model. While long shots were entirely computer generated, medium shots were accomplished by tracking the CG balloon to shots of *Gregor* in the gondola that had been photographed either on a bluescreen stage or suspended from a construction crane.

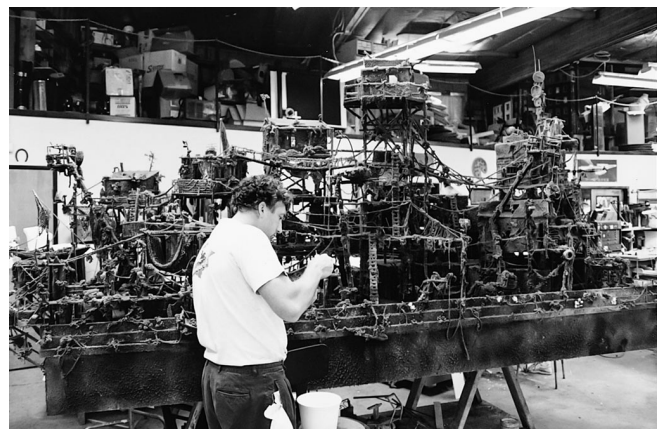
At the climax of the smokers’ attack, the atoll is hit with a spectacular display of gunfire. The product of weeks of preparation, every bullet hit and explosion was carefully planned by Marty Bresin and crew supervisor Eric Rylander. “In the movie, you only see about a quarter of what we did,” Bresin commented. “There is a shot of a 50-caliber machine gun shooting at the atoll. For that, we had 1400 individual bullet hits on the walls. We also had tens of thousands of feet of wire running on the inside – it looked like the inside of a television. These wires branched out to the bullet hits, all the way from the gates of the atoll to *Gregor*’s tower.” The nerve center of this display was a giant firing board. “We had 1400 nails in this giant slot that went across the top of a four-by-eight-foot sheet of plywood.” All 1400 bullet hits went off in a matter of forty seconds, captured with three cameras from a nearby barge and one mounted on a helicopter. “As it ended, you could hear

the echo on the water, followed by silence. After a moment, everyone applauded.” Bresin’s crew also rigged air hoses, pumped with varying volumes of air, to simulate rapid gunfire across the surface of the water.

The distraction of the attack provides the Mariner the opportunity to escape, with the help of Helen who extracts a promise that he will take her and her sought-after charge with him. Freed from his cage, the Mariner dives into the water and swims to his trimaran with the agility and speed of *Flipper*. This, and all the film’s underwater scenes were filmed by Pete Romano, using his Hydroflex cameras and housings. Throughout production, Romano utilized a hard-wire video assist to the surface, enabling Kevin Reynolds to monitor whatever was being filmed below.



For the dive sequence, a city miniature was designed and built by Stetson Visual Services. To avoid the travails of underwater photography, the models were shot dry-for-wet on a stage at VIFX equipped with smoke generators to simulate an underwater environment.



Miniature details included shantytowns perched atop buildings – suggesting how humanity in previous centuries had tried to cope with the ever-rising water levels. Adam Gelbart details one of the makeshift rooftop havens.



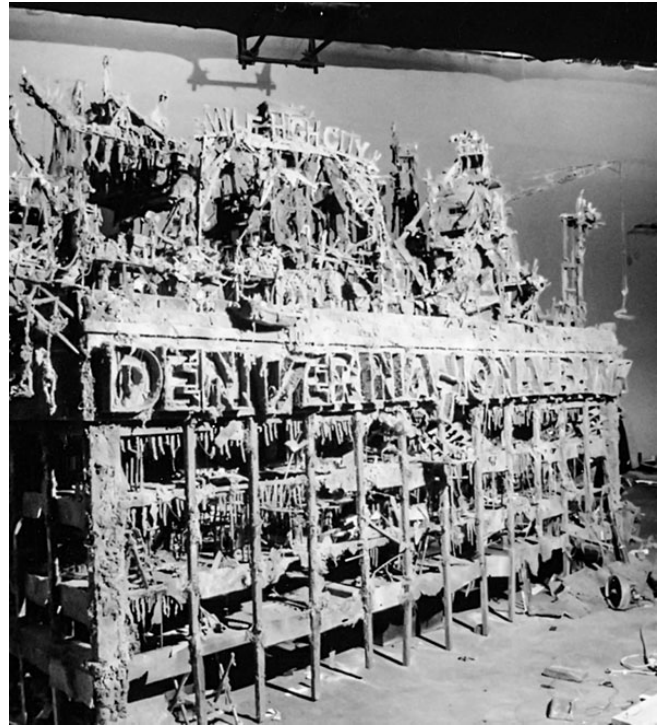
David Schwartz spray-paints a section of the city miniature. In keeping with the pervasive color scheme of the film, the skyscrapers were painted in monochromatic tones to suggest that they had long been covered with rust and algae.

For the swimming shot, Costner was pulled twenty-five feet through the water by a cable, harnessed to Romano, who in turn was harnessed to a hydraulic ram on a track. “Once they started pulling me,” Romano explained, “the cable would become taut, and I’d be pulling Kevin. I was essentially caught in the middle of this tug-of-war. Kevin was holding on to a hand-hold, so he could let go anytime he needed to. I was holding onto a hundred pounds of camera as tightly as I could; because if I let go, it would have slammed right into Kevin’s head.” Since an air tank would have added to the awkwardness and potential danger of the stunt, Romano had to do without until the ram delivered him to the far side of the track, where a safety diver awaited with air.

Once on board the trimaran, the Mariner heads for the massive atoll gate, which Helen and Enola attempt to unlock and open in the midst of smoker gunfire. When Helen is knocked off the gate by a blast, the Mariner grabs onto an ascent line on his trimaran and flies to the top to assist. For the stunt, Costner was attached to a safety line that was removed digitally by Cinesite in postproduction.

Outside the atoll gates, the Mariner and his companions are confronted with the Deacon aboard his boat. To dodge the Deacon and his minions, the Mariner harpoons the machine gun boat – still firing on the atoll – and spins it around so that it is aimed squarely at the Deacon. Because the line on the practical harpoon used in the live-action tended to sag into the water, Computer Film Company was tasked with digitally removing the real line and replacing it with a computer generated cable that would stretch tautly from the trimaran to the gunboat, creating more tension, both visually and dramatically. In its new heading, the machine gun continues firing, inadvertently striking the Deacon’s vessel, which explodes as the Mariner speeds away on the trimaran.

The fiery destruction of the Deacon’s boat – executed by Bresin’s crew, using rings of primer cord – brought the smoker attack sequence to an explosive end. Throughout filming of the attack, the production team took great pains to ensure that the harbor environment was not harmed. Before



The underwater remnants of the Denver National Bank.



Head painter Renee Rabache at work on one of the skeletal buildings.

each shot, a production helicopter would go up to search the area for sea life – a task that was facilitated by the harbor’s exceptionally clear waters, which provided visibility of up to ninety feet. Only when the pilot had signaled that all was clear would shooting commence. “I think in all the time we were there,” Bresin noted, “with all of those explosions, we killed maybe half a dozen fish.” After each take, a crew of up to sixty divers would scour the waters and ocean floor for post-explosion debris, often removing not only the production’s litter, but that left by previous visitors, as well. “The location was far cleaner when we left it than it was when we arrived.”



The sunken nuclear submarine was nearly cut from the deep dive sequence when the film’s producers balked at funding its construction. The image was reinstated when the Stetson team located an existing, appropriately-scaled model at Fantasy II that was subsequently rented and detailed with rust and deep-sea vegetation. The completed shot was nearly identical in composition to Burg’s original illustration.



Stetson crew members ready the sub and city models on stage at VIFX.

Out on the open sea, the Mariner, Enola and Helen are eventually spotted by a scout plane sent by the Deacon, who is determined to capture Enola and decipher her map tattoo. When the scout plane opens fire on the trimaran, a panicked Helen counters the attack by shooting a harpoon toward the aircraft, hitting the gunner and inadvertently hitching the trimaran to the plane via the attached rope. As the airplane circles the trimaran, the rope wraps around the mast, preventing the vessel's escape. The 'plane vs trimaran' scene was carefully storyboarded and choreographed in animatic form by Stefan Dechant, then later executed as an effects sequence. "The whole concept of wrapping the airplane around the boat was obviously not achievable as a real stunt," commented Mike McAlister, "because an airplane would need a runway to take off – which it couldn't get if we had it tied to a boat. So we used a helicopter to double for the airplane, then painted that out and added an airplane in post."

The airplane footage composited into the shots was photographed on a greenscreen stage at Universal Studios. "We took a mockup of the seaplane used in Hawaii, and suspended it from the ceiling with wires," McAlister related. "The camera was on a crane, so we were able to do some interesting choreography to help the sequence out. We used a greenscreen because it needed less light than a bluescreen would. We wanted high f-stops so we could get the depth of field and simulate the bright lighting of the daylight exterior. That setup was expertly lit by Tim Angulo. Cinesite composited the greenscreen elements with the live-action plates." Although rope had been strung between the helicopter and the boat for the live-action shoot, Cinesite had to paint out the real rope and replace it with a 3-D computer generated substitute, since the helicopter – and thus the rope – had not traveled as quickly around the boat as Reynolds wanted.

The Mariner releases his boat from the entanglement, and the trio once again evades the Deacon's grasp. In a subsequent scene, Helen complains about the lack of food and her inability to find fish with a standard fishing rod. Jumping into the ocean, the Mariner allows himself to be dragged behind the trimaran until a gargantuan whalefin fish takes him for bait. As the creature closes its mouth around him, the Mariner uses a double-headed harpoon to blow out its brains – and, in the next scene, the occupants of the trimaran are happily eating fish steaks.

The genesis of the whalefin fish took place in the early months of preproduction, when Steve Burg was busily producing concept illustrations for the film. Although the script indicated originally that the Mariner was swallowed by something that looked like a big whale shark, Burg began to entertain the notion that this creature, a product of a unique world, would be, in itself, unique. In Burg's final drawings, the whalefin fish had shark-like fins, a hammer-shaped head with eyes on either end, and a huge mouth that opened sideways.



Cinesite composited the dry-for-wet miniature photography with underwater footage of Kevin Costner and Jeanne Tripplehorn that was filmed both in open water and in a tank. Digital cleanup included the removal of cables and safety divers. Cinesite composite designer Carol Ashley at work on a deep dive shot.

Troubling the design and execution of the whalefin was the fact that, as storyboarded, the reveal of the creature had been relegated to only a single shot – hardly enough film time to clarify for the audience what the creature looked like, and its function in the story. Attempting to promote the idea of a more fully-realized whalefin, Burg and Dechant – on their own initiative – built and animated a model of the creature in the Video Toaster. “We were trying to sell them on an additional underwater shot that would reveal the whole creature, not just its head,” Dechant explained. “We animated it swimming past camera, showing how it would move, how its mouth would open. We even created a blue background and fog to suggest an underwater environment. We wanted to see this thing coming out of the dark to the watery surface. But we were told to forget it – it wasn’t going to be done that way.”

From Steve Burg’s design – translated into an eighteen-inch maquette by the art department – Rhythm & Hues proceeded to create a computer generated model of the whalefin. Because the head of the creature was going to nearly fill the frame, supervisor Bert Terreri determined that a larger, more detailed model was required; so a new whalefin head – three and a half feet long – was sculpted, then digitized to create a basis for the computer model. Subsequent texture maps were designed to reflect the look in Burg’s concept drawings. “The color sketch implied that the whalefin had dark skin with white spots, like a sperm whale,” said Terreri. “We experimented with different textures, teeth, folds and lighting schemes to give it an even more menacing appearance. We also paid a lot of attention to the mouth. For a few frames, the open mouth needed to occupy about eighty-five percent of the frame; so we had to spend a lot of time in that area, figuring out how the teeth looked, how they attached to the gums, et cetera.”

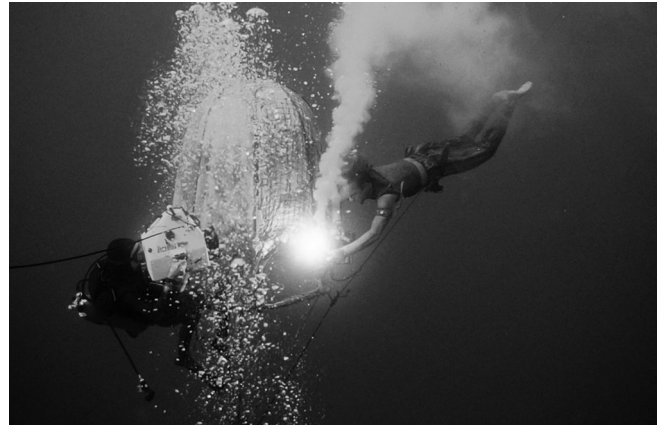
Creating a whalefin that moved like a fish was also an important part of the task. “The whalefin needed flexibility,” noted Terreri. “Nancy Kato, one of our animators, spent quite a bit of time putting control points on the model to make it flow. When Mike McAlister wanted the tail to swing in either direction, for example, the control points gave it some fluidity, so it wouldn’t move like a stick.”

While the whalefin’s exterior was computer generated, its esophagus was built practically by Marty Bresin and his crew to accomplish shots of the Mariner being engulfed. With engineering supervisor Ralph Kerr, Bresin created an oval, fish-like mouth, connected to a large wind sock. The movement of the practical rig through the water was controlled by a multiple string-and-handle device, similar to that used in operating two- and four-string kites. Costner was pulled through the water by cables extending from the wind sock to a pneumatically powered slide on board a camera barge. “Once he was up to speed,” noted Bresin, “one person would throw a lever on the slide, causing the mouth to rise out of the water. Another guy would then throw a valve, slowing Costner down so that the mouth would overtake him, appearing to swallow him.”

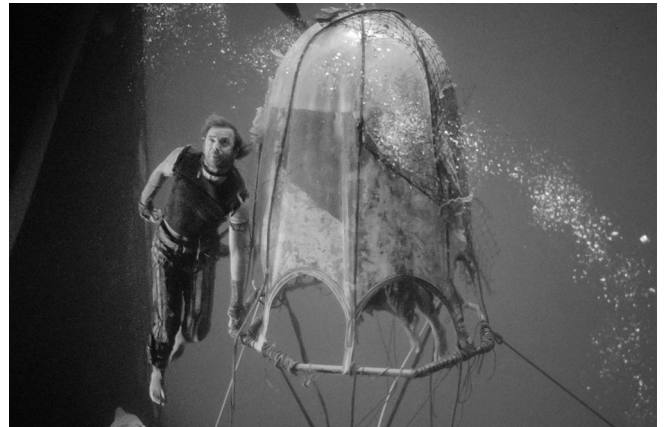
In post, the CG whalefin was married to the live-action, with Rhythm & Hues adding interactive CG water effects to create the illusion of the creature breaking the surface of the water. “We mapped the ocean on top of a geometry,” said Terreri, “so when the creature moved one way, it created a trough; and when it moved the other direction, it created a swell. We also added particles and splashes from stock footage of ski jumps. Every frame had to be pieced together.”

Despite the extensive work that went into the whalefin, early test screenings revealed that – as Burg and Dechant had feared – the three-second shot lacked dramatic impact. “The problem from the beginning,” McAlister commented, “was that this one shot was expected to achieve dramatic tension, buildup and a resolution for this story point. It was unrealistic to expect one shot to do all of that.” Only a few weeks before the film’s release, effects veteran John Bruno was brought in to look at the sequence with a fresh eye and provide a possible solution. “John’s job was to figure out what could be done, editorially, to take some of the pressure off this one visual effects shot that was being asked to work miracles.” Bruno responded by organizing a short-notice shoot – commandeering and hastily re-skinning the ‘Jaws’ shark from the Universal Studios tour – to create a beginning, middle and end for the sequence.

The Mariner’s gradual softening toward his female companions is illustrated in a sequence in which he teaches Enola to swim. Underwater footage for the montage was shot by Pete Romano in open ocean waters. Cinesite contributed to the sequence by removing flippers worn by Costner in the scene, and replacing them with webbed feet. “The kinds of things he was doing in the water required Costner to wear flippers,” said Brad Kuehn. “But, of course, the Mariner would have no need for flippers. They managed to keep his feet out of the shots most of the time; but in one shot, his foot kicked into the foreground, and the flipper was right there.” An extensive digital paint job was required to save the shot. “Fortunately,” said Jamie Price, “there were lots of bubbles to help us blend it. Kevin Lingenfelser rotoscoped the foot, then composited into that area a clean section of water, along with some bubbles he stole from an adjacent area. It blended right in.”



Early shots in the deep dive were filmed in Hawaii by underwater cameraman Pete Romano. To avoid the need for artificial lighting, the action was photographed in ocean waters only about forty feet deep. Romano keeps pace with Costner as he makes his initial descent. In postproduction, Cinesite replaced the electrical light carried by the actor with a flare and removed the attached cables.



Deep-water shots were filmed against a rear-lit bluescreen in a tank at the McDonnell Douglas facility in Long Beach. To avoid having to light enormous areas of the tank, the actors were photographed within a limited space, remaining more or less stationary as a jet-stream of water was pumped past them. The diving bell in the scene was designed and built by Peter Chesney.

Shortly after the swim montage, a floating outpost manned by waving well-wishers comes into view. As the trimaran approaches, it becomes clear that the waving drifters are, in fact, dead – their bodies and arms rigged by the on-board Deacon and crew to lure the trimaran. Unaware of the con until he is perilously close, the Mariner must take extreme measures to outrun his adversaries. From a small cannon, the Mariner ejects a spinnaker kite that catches the wind and carries the trimaran out of the smokers' reach. The spinnaker kite was a CG element produced at Rhythm & Hues. "We applied a cheesecloth texture so that it looked canvas-like," revealed Bert Terreri. "Then we painted some textures to age it and give it the look of a bad sewing job."

While the look of the kite was fairly easy to produce in the digital realm, its organic unfurling motion required much trial and error before Terreri and his team were satisfied. "It finally occurred to us to think of it as a very slow mortar," Terreri recalled, "something that had some life, was not too busy, and that unfolded in front of you." Mike McAlister's brother, Tom – an internationally known kite-maker and owner of HiLine Kites of Berkeley – built a 3-D toy from balsa and tracing paper for Rhythm & Hues to use as reference. "That came in extremely handy because we needed to understand the methodology for how it unfurled – something no one could draw."

Having again outwitted the Deacon, the Mariner leads Helen down to the bottom of the ocean, where what was once the city of Denver lies. The deep dive was one of the most complex and challenging effects sequences in *Waterworld*. "There were only a couple of ways we could do this," McAlister noted. "One was to build a huge set in large tanks, like they did for *The Abyss*. The problem with that was that the set would have had less scope than we wanted. The other alternative – the one we decided on – was to build and shoot a miniature, film the actors against underwater bluescreen, then composite them together." To avoid the almost insurmountable problems of filming miniatures underwater, the decision was made to shoot them dry-for-wet.

Design, construction and filming of the miniature Denver set was awarded to Stetson Visual Services. "Mark Stetson shepherded the whole building and shooting of the miniatures for me," McAlister explained, "working closely with visual effects director of photography Alex Funke. I was very involved directorially, in terms of designing shots, setting up shots, and helping where I could with the design of the lighting. But Mark took the major hands-on role in supervising the miniatures from beginning to end."

Before construction began on the set, the Stetson design team, headed by George Trimmer, devised a proposal in videomatic form. "We got a sense of what the city should look like from Dennis Gassner," Mark Stetson said. "Dennis picked the Denver buildings he wanted to see – although they were moved around and reconfigured." Once design renderings had been approved, crew chief Ian Hunter produced mockups of the cityscape made from foamcore covered with blueprints and xeroxes. Hunter then supervised videomatic tests, using a Hi-8 cam corder, that included smoke and even a soundtrack provided by Brian Eno's 'Whalesongs.' "All of that was done in-house. We arranged the mockups in an eight-foot cube that we filled with smoke and lined with blue tarps to create a natural, water-like blue tint."

After McAlister approved the videomatic, the Stetson team began construction of the city model in two scales. "Most of the model was done in 24th-scale," said Stetson. "There was one section done in twelfth-scale for a particular shot in which the camera tracked laterally across a foreground of

devastated buildings with girders and bent-up metal. Because that shot was going to be played very close to camera, we wanted to be able to put in better detail – that was the reason for the larger scale.” Due to the density of the smoke in which the models would be photographed, only eight to ten buildings – moved around and reconfigured for each take – were required to create the entire cityscape.

Building of the miniature was very much like a full-scale construction project. “The work was difficult in the sense that we had to frame the entire depth of every building,” Stetson observed. “However, it was easy in the sense that anytime we ran into some kind of problem with the miniature, we could cover it with debris or rubble.” Floor sections of the buildings were built out of foamcore – made to resemble broken concrete – and framed in aluminum.

To support the notion that the city had been submerged in water for centuries, the color scheme of the miniature was decidedly monochromatic. “We followed the logic that Dennis Gassner had established in the live-action,” said Stetson. “Any painted structures would have long been overridden by rust or algae; so key painter Renee Rabache used a lot of algae colors in the model.”

The completed miniature was assembled and photographed on a VIFX stage equipped with a smoke machine designed to maintain consistent smoke density throughout filming. “That was crucial to the success of our job,” Stetson remarked. “The machine was controlled by infrared sensor, with a sender and a receiver that were placed in various spots in the room. An automated meter fed smoke fluid to the machine as needed, maintaining a consistent level of smoke. For the long-duration shots we were doing, that was very important.”

For each shot, the miniature was filmed both with and without smoke, resulting in a smoke pass and a clean pass that could be composited to create the appropriate density. “It was essential for us to be able to control the amount of smoke and haze in postproduction,” noted McAlister. “We weren’t sure exactly how much would look right. In some of these shots, the composition was such that we were essentially looking down into half a mile of water – and there is no ocean on the planet that has that kind of visibility. So we were taking creative license in that regard. At the same time, we had to establish that Helen and the Mariner were in very deep water – which meant there would be a lack of clarity. By shooting an extremely smoky pass, and then a clean pass, we could adjust the mixture between the two later.”

The centerpiece image of the sequence – a long-dormant nuclear submarine lodged in the rubble of the city – almost failed to make it into the film. The image had first been conceived in a painting by Steve Burg. “I thought about what would be the last thing to go if the world were suddenly flooded with water,” Burg explained. “From my work on *The Abyss*, I knew a lot about nuclear submarines; and I knew that they can operate underwater almost indefinitely. A nuclear sub and its crew would survive until they ran out of food. I thought it made sense – and would be very cool – to have a submarine crashed like an airplane in a city street.”

Mark Stetson was equally enamored with the idea. “It said everything of what the film was about,” Stetson commented. “It was post-apocalyptic in that it was one of the last pieces of technology that we can imagine surviving in a full water environment. To have it crashed against these ghosts of skyscrapers was a beautiful concept.” Despite Stetson’s enthusiasm, budgetary issues threatened the demise of the submarine shot. “The producers didn’t want to have to pay for the construction of a submarine model. Fortunately, we found one in the correct scale at Fantasy II. It had been used in a movie that was never released, and it was just sitting there in their yard. So we rented it from them and turned it into this derelict sub covered with weeds and rust. We photographed it, composing the shot almost identically to Steve Burg’s original illustration. It turned out to be our favorite shot in the movie.”

Composited with the miniature photography was underwater bluescreen footage of Costner and Tripplehorn and their stunt doubles, filmed in a large tank at the McDonnell Douglas facility in Long Beach. An initial shot of the characters beginning their deep dive had already been photographed in open water in Hawaii. Both the tank and the location footage featured a diving bell that, in the story, would create an air pocket, providing oxygen for Helen to breathe as the Mariner pulls her down to the ocean floor.

Designed by Peter Chesney, the diving bell was built out of heavy-gauge vinyls and nylon webbing stretched across an aluminum frame. For the open-water scene, the aquadome was attached by lines to moorings on the ocean floor, ninety feet underwater. A navy winch was used to pull the device from the surface to the submerged moorings.

Before it was employed in the open water, however, the diving bell was put through vigorous testing to ensure its endurance and safety. “We built one bell and tested it in my mother’s pool,” recalled Chesney. “It would have been catastrophic if this thing had ripped and failed during shooting. The amount of air in the bell created 1200 to 1400 pounds of buoyancy. That is a substantial volume of air – and it meant that we needed that much weight to hold it underwater; otherwise, it would



The film’s finale takes place on the Exxon Valdez, the derelict home base of the smokers and their leader, the Deacon. The ‘Deez was realized primarily through a full-scale deck set – built in the City of Commerce – and a complete eighth-scale miniature constructed by Stetson Visual Services. A scene in which the Deacon addresses his followers from the bridge of the tanker was shot on the six-hundred-foot-long Commerce set. At Cinesite, more than forty ‘Deez shots were image processed to digitally remove all signs of dry land. Blue plastic surrounding the set served as a roto-scoping aid.



After the desired live-action was isolated, Cinesite added a computer generated ocean, employing water simulation software developed by Areté Associates, a company known for highly accurate oceanographic and atmospheric studies.

never sink. We weighed it down with 1200 pounds of lead, tested it up to double loads, then made final design improvements that were incorporated in a pair of hero diving bell units.”

One of the issues that had to be addressed in the design was the inevitable compression of air volume that would take place as the diving bell descended into deep waters. “By Boyle’s law,” explained Chesney, “you lose half your volume of air at thirty-three feet deep. At sixty-six feet, you’re at one-quarter of your volume; at ninety-nine feet, you’re at one-fifth. That air has to be replaced on the way down. We pumped air in from tanks hidden in the base of the bell to replace the lost volume as it lowered, and maintained volume on the way up with air holes in the bell.”

Chesney made the first deep-water test ride in the diving bell prototype. “I rode it down forty-five feet from the surface, and back up several times, without wearing scuba gear – although I did have safety air nearby.” After several test runs, world champion free-diver Greg Burnett – acting as Costner’s double – dressed like the Mariner and made an eighty-foot descent in thirty seconds, holding onto the bell. A stuntwoman doubled for Jeanne Tripplehorn in the shot.

Costner and Tripplehorn were featured in the majority of the shots, however, and were required to do much of the diving themselves. For the initial shot in the sequence, for example, Costner – with Tripplehorn inside the bell – begins to descend as the camera follows. “I panned with him as he disappeared into the blue,” explained Pete Romano. “We had to be in very deep water there, because he was supposed to be going down a couple of thousand feet. He had to go into the stark, beautiful blue water; and it had to get deeper and darker all the time. We could never have replicated that kind of scope and feeling of depth in a tank. We had to do that initial shot in the ocean.”

Fortunately, Costner, Romano and crew did not have to actually dive the thousands of feet specified in the story. The deep-dive opening was accomplished in water that was only about forty feet deep. “If we had gone much deeper than that, we would have needed artificial lighting and a whole lighting crew. It wasn’t practical – and it wasn’t necessary.”

The remaining shots in the sequence were accomplished in the McDonnell Douglas tank in Long Beach. The tank – 33 feet deep and 70 feet in diameter – had been used previously for NASA testing purposes. McAlister’s strategy was to film the actors against an underwater bluescreen, then composite just their images – not the surrounding water – into the dry-for-wet miniature photography. “The whole reason for shooting them underwater,” McAlister explained, “as opposed to suspending them on wires, was to get all the natural movement you get in water – the movement of the hair, the clothing, the little tassels on the diving bell and the resistance of the water against the actors’ bodies.” Rather than have the actors actually swim through the water in the tank, water was blown past them as they remained relatively stationary. “That was a better way to do it, because it meant we didn’t have to light such a large area. We shot them against bluescreen, more or less standing still, while rotating and changing their body attitudes to correlate to whatever was going on in the backgrounds. We had two huge pumps that sent streams of water past them, like underwater fans. The jet stream made it look as if Costner was moving through the water, but he was actually just swimming in place. It was like an aqua-treadmill.”

The actors and their doubles were photographed in front of a 24x36-foot transmission bluescreen – the largest rear-lit bluescreen ever put underwater. The biggest challenge of the shoot was overcoming the cloudy conditions within the tank – the result of old paint rubbing off the sides of

the tank and dust floating off the grip and lighting equipment. “We would have preferred shooting in clearer water,” McAlister commented. “Because the water was so cloudy, all of those minute bits of matter were lit up by the blue light. That resulted in a mushy image, with all of our foreground characters getting contaminated by blue spill. We found that the water was relatively clear in the mornings, becoming increasingly cloudy as the day wore on; so we tried to do our wide shots in the morning, going in for closeups at the end of the day.”

In order to match the camera moves established in the miniature photography shot on the VIFX stage, Romano had to act as a kind of human motion control unit during the bluescreen tank shoot. “I was in a harness,” Romano recollected, “being pulled backwards, sideways or up by a winch – at the same time, holding onto the camera, focusing, pulling stops and framing, all without the benefit of an air supply. I couldn’t wear a tank because the bubbles would get in the way.”

At Cinesite, the dry-for-wet miniature photography and tank footage were composited into a cohesive sequence. Compositing tasks included painting out both wires and safety divers. In addition, because of the limited space within the tank, the illusion of a vast underwater environment had to be achieved with overriding moves added in postproduction. “We also had to bring the color of the entire sequence into line,” Jamie Price recalled, “so that there would be a smooth transition from the near-surface shots to those in the dark and deep-blue water. For each of our composites, we had to make a transition from the actual footage shot in the ocean, to the footage filmed in the tank, to pure composite.”

Cinesite was also charged with adding CG particles and minutiae that would interact with the characters, making them look as if they were moving through water rather than the smoke used in the background miniature plates. “When we did the bluescreen extraction,” Brad Kuehn explained, “we were left with the Mariner and Helen in the bell – but we had lost the water that surrounded them. As a result, all of the cues showing the audience that the characters were in water were also lost. Mike McAlister turned to us for a 3-D solution to recreate those cues, and to create the illusion of the Mariner swimming through fluid and interacting with a watery environment.”

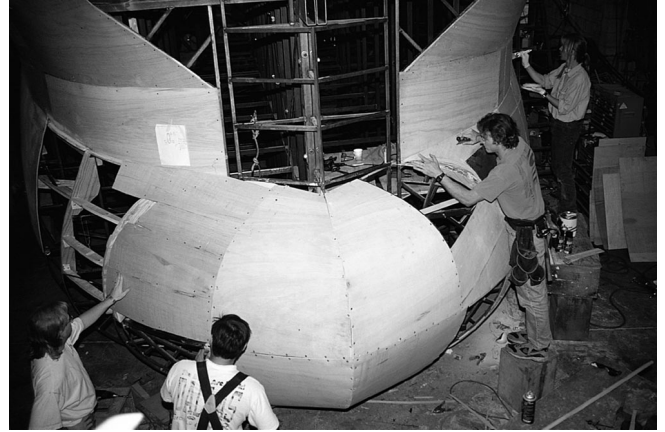
The focal point for the interactive effects was the flare carried by the Mariner as he descends. In the bluescreen footage, Costner actually carried an electrical torch connected to a cable. Cinesite rotoscoped the torch, painted it out, and added a CG flare and bubbles. “That flare provided a good point of reference for adding the minutiae that would make it appear he was moving through water,” remarked 3-D supervisor Wendy Rogers. “We could track our interactive particles – which we created primarily with Wavefront’s Dynamation – to the flare that he was holding.”

After the dive, the Mariner and Helen surface to find the trimaran overrun by the Deacon and his smokers. Seizing Enola, the smokers open fire on Helen and the Mariner, who dive deep into the ocean, out of harm’s way, as gunshots riddle the surface. To enable Helen to breathe, the Mariner brings her lips to his and feeds her oxygen from his gills. On location, shots of the two characters diving and swimming were realized without gunfire effects. “Later, we went into my swimming pool,” explained McAlister, “and, with an air gun, shot ball bearings into it, against black fabric. We filmed it on Hi-8 videotape, which was later digitized and composited into those shots using a Flame. The nice thing about working digitally is that the computer doesn’t care where the image comes from, as long as you have sufficient resolution. In this case, we shot bullet trails full-frame on

Hi-8 tape, shrank them down into a frame that had 2K resolution, and it worked very well. We saved about \$5,000 by not shooting on film.”

When they emerge, the Mariner and Helen find Enola gone and the trimaran destroyed. Without food, water or supplies, they float aboard the drifting wreckage, their eventual deaths a certainty. Suddenly, *Gregor* appears overhead in his balloon and transports them to safety aboard a lifeboat occupied by a small band of atoll survivors. On a Jet Ski stolen from a dead smoker, the Mariner sets out to search for Enola and her captors. Through a thick fog bank, he discovers the huge, mysterious vessel that serves as the smokers’ fortress – the ‘Deez. The massive oil tanker – the infamous *Exxon Valdez* – was first conceived in a series of Steve Burg sketches. “They wanted the ‘Deez to have a satirical edge,” Burg recalled. “In my drawings, the tanker ended up looking kind of skull-like, with big holes all over it. I came up with that visual first – then I had to figure out the rationale for why it would look like that. My first idea was that it had just rotted away with age and decay. But then the producers came up with the idea of the smokers using metal taken from the ship as bullets. It was an appropriate metaphor for our times – people eating away at the thing that is sustaining them.”

Although the ‘Deez appears to be the real thing in the film, for production purposes, the massive oil tanker did not actually exist in its entirety. Instead, the ship was realized through the skillful combining of a full-size deck set, a small, full-scale section of the hull, full-scale interior sets, and an elaborate eighth-scale model built by Stetson Visual Services – the last project completed by the company before Mark Stetson and co-founder Robert Spurlock closed its doors. The explosive destruction of the ‘Deez that occurs in the film’s climax was the deciding factor in determining a scale for the model. “We looked at a lot of footage from recent films,” Stetson related, “projects where we knew the scale of the miniatures involved, and decided that eighth-scale – an inch and a half to the foot – was the minimum we would want to work in for the explosion effects. Even at that relatively small scale, the model was huge. The actual *Exxon Valdez* is 987 feet long, so our model was approximately 110 feet – big enough for wide establishing shots. In commercial ocean vessel terms, anything over one hundred feet is a ship. So this model was technically a ship – it just never had to float.”



Measuring more than a hundred feet in length, the ‘Deez miniature was the largest model ever built by Stetson Visual Services. Constructed in twelve separate segments, the ship consisted of a welded steel framework covered with a veneer of wood and metal sheeting. Crew members assemble the bow section of the vessel.



Once completed, individual model sections were loaded onto trucks and transported to Mojave Airport, a desert location selected by Mike McAlister for its ample working space and unobstructed horizon lines.

Design of the 'Deez model was a collaborative effort between the Stetson crew and Dennis Gassner, with SVS's George Trimmer concentrating on the hull. Once designs were approved, Stetson had them evaluated by an engineer to ensure that the aesthetic choices were also structurally sound. "We actually hired my dad, Paul Stetson, who spent his career in the aerospace industry. He lives in Massachusetts, so we faxed and FedExed the drawings back and forth to him. The drawings required a formal design analysis – down to the way the materials were welded and joined – to make sure the model would be sound. We also worked with *Mark West*, an engineer who has consulted on many film projects. Mark made the on-site inspections and corrections from an engineering standpoint."

The basic structure was made of steel, and consisted of twelve segments, each ten feet long. Those segments were bolted and welded together, then covered by a skin made primarily of wood. An exterior of thin metal sheeting allowed for the adding of rivet and welding detail.

"This model was the single largest object ever to come out of our shop," Stetson stated. "We had a floor space seventy feet long and thirty feet wide; so, at best, we could only have half of the model in the shop at any one time. There were times when we had the ship's stern and bow in the shop in their normal configuration – except there was no midsection. It looked like a cartoon boat. It was funny to see this huge object in such a tight space – it was the classic boat-in-the-basement syndrome." So tight was the space that the ship model had been designed down to the inch to ensure that it would fit through the shop doors. "When the moment of truth came, we were all biting our nails. But we were also proud. We knew this was our last project; and it was nice to see something so big and so well done go out the door like that. We delivered the model at the end of the year, just before Christmas. Then we all joined the film's production staff. Stetson Visual Services was suddenly a happy memory."

The completed model was transported to the Mojave Airport, an unlikely desert location Mike McAlister had chosen for the miniature shoot. "A lot of people in the industry were surprised when I made that choice," McAlister admitted. "But as I started scouting locations near the water, I found that there were many restrictions imposed by the air quality board in terms of what we could do with fire and smoke. The other problem was that, even if the boat was built in eighth-scale and photographed in water, the shots weren't going to look as real as I wanted them to. We would have had to doctor the water anyway to achieve a good relative scale – so why bother shooting on water at all? As they had already found out with first unit, water severely complicates filming. Adding water to a shot that was made in the desert was technically the same as adding water to a shot that was made on the water. So I decided to give myself a break."

The advantages to shooting in Mojave were many. "The people there bend over backwards to help you make films," related McAlister. "The Mojave Airport had everything we needed – a huge hangar that served as a staging area, workspace, big tarmacs and little airplane traffic. On top of that, the winds there are very predictable. It also had a horizon that would help us to keep track of where the water would be. There was garbage everywhere – old jet parts, hangars, mountains – but we got rid of all of that in post."

Visual effects-wise, the third act of *Waterworld* begins with the Mariner arriving at the 'Deez. Cruising through the fog on his Jet Ski, he comes upon a massive obstruction covered in barnacles

and rust. Not knowing what he has discovered, the Mariner starts to climb, fitting his hands and feet into holes carved into the hull by smokers cannibalizing the ship for bullets. “We did three shots that establish the Mariner climbing up the side of the ship,” McAlister said. “Two of them were filmed in a tank at Paramount, on a set piece that was thirty feet tall and sixty feet long. We shot the foreground element of the Mariner hanging on this set piece, then matched that angle with our miniature in the desert. A soft split was created between the two elements; and water was added down below, off to the horizon. Over the top of the whole shot, Cinesite added lifting fog – computer generated – so that we could reveal the boat appearing through the mist. From there, we cut to a split that began with an element shot on the set piece at Paramount, then tilted up past a pipe onto a full-size mockup of the deck that was built and filmed in the City of Commerce.”

The Commerce deck set was six hundred feet long, with a forced-perspective bow and stern that, when viewed from one end to the other, made the ship appear to be nine hundred feet long. Among the scenes shot on the full-scale set was one in which the Deacon delivers a histrionic sermon, inspiring solidarity among his minions in the search for Dryland.

While the Mojave Airport had been an unusual location for filming of the miniature, the choice of the Commerce site was downright courageous. The full-scale deck set – built in an open field in the middle of a busy urban area – had rooftops, telephone poles, trees, airplanes landing at nearby LAX, and mountains as background, all of which had to be replaced with endless water and sky. “Before-and-after stills of the full-scale set are staggering in terms of the boldness of that choice,” McAlister marveled. “All of that garbage had to be removed in forty to fifty key shots.”

Cinesite was the effects firm faced with the monumental cleanup task. Fortunately, bluescreen had been used in some of the shots of the Deacon on the bridge, simplifying the touchup work. “We hung a big bluescreen outside the set,” explained McAlister. “So as the Deacon walks out the pilot house door – where the mattes were critical – we could at least pan him through a portion of bluescreen and not have to rotoscope him out of the cityscape background. The camera continues to pan down to the boat, the perimeter of which we had lined with blue plastic. Initially, we thought we’d be able to pull mattes off of that. But, because the filming in Commerce took place during the rainiest January in Los Angeles history, the blue plastic became a big muddy mess. It still turned out to be useful as a roto aide, though, allowing the artists at Cinesite to clearly see what was boat and what was non-boat.”



Cinesite Digital effects supervisor Jamie Price studies a composite.



In a farcical moment, the Deacon instructs his minions to row the massive 'Deez toward Dryland. For a shot of oars lowering into the sea, the Stetson model was photographed on scaffolding. Cinesite then added a water plate, interactive splash elements and computer generated oars.



The model is maneuvered by crane onto the Mojave Airport apron.

Both real water footage and computer generated water were used to place the full-scale set and the miniature in the ocean. “Where the lighting direction and camera angles were predictable and static enough,” McAlister said, “we used background plates of real water. But in cases where we had these big, sweeping camera moves, we couldn’t just lock the camera off. My idea was to shoot the live-action with a Steadicam and hammer out the compositing details later – and that’s what we ended up doing. Kevin Reynolds shot whatever moves he wanted; then we used computer generated water, which we could control. We could control the color, the ocean swells, and the amount of wind chop on the surface, so that it would match from cut to cut. This was one of the big breakthroughs on *Waterworld*. I went into this movie thinking that I would have to shoot real water plates for everything. But Cinesite provided computer generated water that was absolutely real looking. I would give them a shot of real water as reference; and a few weeks later, they would come back with CG water that looked exactly like what I’d given them.”

To realize the CG water elements, Cinesite utilized water simulation software developed by Areté Associates. “Areté does oceanographic and atmospheric studies for the government,” Jamie Price explained. “They have PhDs who have studied fluid and atmospheric dynamics – and they’ve come up with this software that allows you to simulate those dynamics.”

The Areté software employs a grid that allows for the creation of a height field. “From that,” said Brad Kuehn, “they can calculate how high the water is going to be at a given pixel on the screen, based on wind speed. They sum up all of the forces that contribute to the height of the water at that pixel – so if the waves are in a certain position, they take the sun and create a little highlight balance. That gave us the ability to determine the characteristics of the sparkle on the water. There was a shimmering in the distance – but up close, there were individual highlights on each wave crest.”

“The height of the sun would affect how wide the highlights on the ocean would be and what position the sun would be relative to the horizon,” Price elaborated. “We could input all of those variables. Areté’s simulations are all physically accurate – which was the source of a lot of fun. I would say, ‘We need brighter highlights.’ And they would say, ‘But this is how bright the sun is.’ I’d



When the Mariner drops a burning flare into the tanker’s massive hold, its treasured oil reserves explode and the ship sinks. Cinesite composited model photography with water plates – both real and computer generated – throughout the sequence.



In a daring stunt, the Mariner bungee-jumps from a hot air balloon to rescue Enola from the ocean waters below. Boss Film Studios composited a computer generated balloon with a live-action gondola and bluescreen footage of Costner’s jump.

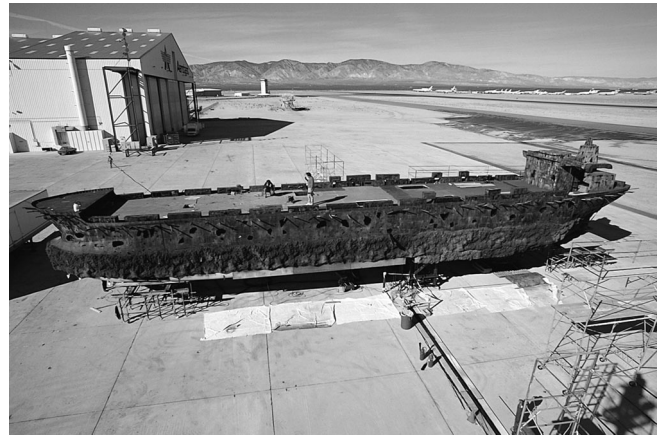
tell them, ‘Well, I’d like the sun to be ten times brighter today.’ I think we taught them to appreciate the concept of dramatic license.”

At the end of his sermon, the Deacon sends his smokers below deck to row the giant ship towards Dryland. While other scenes came and went during *Waterworld*’s beleaguered production, Reynolds never wavered in his intention to include this farcical image in the film. “Kevin clung to that idea like a madman,” McAlister laughed. “These oars come out of the side of the ship and start rowing – which is pretty funny, considering the size of this thing. We chose to do the oars as CG elements, just in case the shot was cut, since it would have been very expensive to build and mechanize them. By doing them as CG elements, we could leave them until the end when the decision to include the shot had definitely been made.”

To make it appear that there were twice as many rowers as were actually on the live-action interior set, McAlister shot a plate of the smokers in one position, then moved the camera back the length of the set and shot another plate. Those two images were seamed together at Cinesite to create a long line of rowers. The film then cuts to a shot outside the ship, with the CG oars coming out and dipping into the water. To achieve that shot, the ‘Deez miniature in Mojave was put up on a scaffold. “We added a water plate to that,” stated Jamie Price, “as well as a CG wave matte to interact with the hull. Finally, we added the 3-D oars, rendered in such a way that they would come out of the holes. For the shot of them interacting with the water, we used splash elements filmed on stage.”

“The camera was quite close in the shot,” Wendy Rogers added, “so that interaction had to look as realistic as possible – and there is nothing better than real water for that. In the following wide shot, we created CG water that reacted as if the oars were moving through it. That shot was far away, so the look of it was not as critical.”

Having cleared the deck, the Deacon is confronted by the lone Mariner. When the Deacon refuses to release Enola, the Mariner drops a single flare into the tanker’s oil pit below deck, causing the ship to explode and sink in a cataclysmic display. “One of the challenges of the third act was the burning and sinking of the ‘Deez,” McAlister commented. “We went around in circles for the longest time, trying to figure out where to build this full-size mockup of the



The Exxon Valdez model – fully assembled, but without deck dressing – sits on the ramp at Mojave Airport. SVS co-owner Robert Spurlock oversaw the shoot, which included a slate of miniature pyrotechnic shots for the climactic burning of the ‘Deez.



To achieve shots of the ship sinking into the sea, the stern section of the model was elevated by a construction crane. Although the tanker model would be composited with water for its floating scenes, a temporary pool was built in the desert to realize the appropriate interaction of sea and ship as the ‘Deez slips beneath the waves. Weighted with steel to make it sink as quickly and dramatically as

deck so that we could do all of the explosions and fire for real. Of course, in the City of Commerce, there were legitimate restrictions as to how much black smoke we could put into the air on any particular day. In addition, black smoke is, by definition, toxic; and you can't have your multimillion-dollar movie star running around in a toxic environment. For those reasons, the decision was made to use minimal black smoke on the set, and add considerably more in postproduction. Smoke additions ended up accounting for about eighty composite shots in the third act."

possible, the model was lifted by a crane and lowered into the pool.

A large number of smoke elements were shot at the Mojave Desert, then turned over to Cinesite – and a number of other companies – for compositing. "We had actually experimented with 3-D smoke," Brad Kuehn noted, "just to see if it was possible. But there wasn't time to go into a major research and development effort; so Mike shot the smoke as stage elements, which we matted in, along with all the CG water."

From the bridge of the burning ship, the Mariner harpoons the Deacon's airplane just as it is about to take off from the deck below. Clinging to a grappling hook, the Mariner then slides down a cable towards the plane. Costner executed the stunt himself at the Commerce set, where nine thousand gallons of propane were used each day to create the explosions in the background. Marty Bresin's team oversaw the pyrotechnic work and devised a rig for the slide. "When you see Kevin Costner coming down with all of those explosions behind him," Bresin commented, "that was really Kevin Costner coming down with those explosions behind him. Safety was the most important thing. Jeff Pepiot, who did most of my machine work, built a special slide with a brake. If Costner came down the cable too fast, he could pull the brake and slow himself down." The pulley brake was painted out by Cinesite, and digitally replaced with a painted grappling hook to make the stunt appear more daring.

While much mayhem was created practically on the Commerce set, the final explosion and sinking of the 'Deez was accomplished with the eighth-scale miniature in Mojave. Robert Spurlock oversaw the shoot, with pyro work headed up by John Stirber and Roy Downey, assisted by Roy Goode, Pia Montanta and Richard Stutsman. "Bob and John worked out a sequence of events for the explosion and sinking of the ship," noted Mark Stetson, "and then they proposed those ideas to Mike McAlister. Together, the three of them worked out how to accomplish the miniature pyro. They used large fans with jets of propane behind them, propane mortars and fire boxes. There were something like sixty separate fire boxes and mortars scattered around the perimeter of the ship to achieve the big finale. Normally, we would stagger an event like that, creating a chain of events to make the ship look larger in scale. But Mike wanted to see the final explosion happen as a single event. I think his idea of the timing was right – there is all of this buildup, and then the whole ship is engulfed in one big explosion."

One shot in the finale revealed deck debris tumbling toward camera as the upturned ship begins to sink. The 'Deez model, which had been assembled in two main sections, was split in half for the shot. "The bow was removed, and the stern was lifted by a 75-ton construction crane," said Stetson. "The Mariner, who has just rescued the little girl from the Deacon's crashing airplane, turns around and sees all of these containers and deck debris falling toward him. We attached the camera onto

the deck of the model, and literally lifted the model into the air by crane so that all of the debris would tumble naturally toward the lens.”

In the final shot in the ‘Deez destruction sequence, the ship sinks below the waves, revealing the long-forgotten moniker, ‘Exxon Valdez,’ emblazoned across its stern. To capture realistic interaction between the sinking ship and the water, McAlister commissioned the building of a temporary pool in the Mojave Desert. Adjacent to the airport’s concrete apron, a local contractor excavated a giant hole that was then lined with gunite, sealed and filled with water. A ten-foot section of the tanker model was lifted by the crane and lowered into the pool. Special venting incorporated into the model allowed air to escape quickly so that the ship would sink properly. “We weighted it with another thousand pounds of steel to help pull it beneath the water faster,” Stetson said. “When we were finished shooting, we just filled the hole back up.”

Stranded on the sinking ship, the Mariner and Enola are rescued by *Gregor* in his balloon, accompanied by Helen and several atoll survivors. In the course of the rescue, Enola falls from the gondola into the ocean below. As the Deacon and two smokers race to sweep her up, the Mariner grabs a line, wraps it around his waist, and plunges from the sky in what proves to be the mother of all bungee jumps. Snatching Enola from the smokers’ path, the Mariner delivers the little girl to the gondola, while the smokers and the Deacon crash and are engulfed in the explosion. Two bungee jumps were filmed against a bluescreen and composited with CG balloon and gondola footage by Boss Film.

With the rescue and subsequent discovery of Dryland, *Waterworld* comes to a close. One of the first previews of the much anticipated film was scheduled for March 29. Since principal photography had wrapped just eight weeks prior to the screening, the time crunch for the visual effects team was such that, in order to have a completed third act by that date, 160 shots were temporarily composited in video at Editel. “We wanted at least temporary composites in the movie, rather than ‘scene missing’ leaders,” explained McAlister. “Six weeks after principal photography wrapped, we had a movie with all the visual effects shots in. Some of them looked pretty rough, but at least the story content was there.”

McAlister, like many of the principals on *Waterworld*, considers the project to have been his most challenging undertaking to date. Months after the movie’s completion, the visual effects supervisor expressed pride in the work his team had accomplished. “We managed to complete more than three hundred effects shots in record time – many of them virtually invisible,” McAlister noted. “This was the most ambitious film ever to be attempted on water. In Hollywood, many movies are made that are similar to each other in terms of production demands – and a tremendous level of experience can be brought to those movies. But almost no movies are shot on water, so there is very little expertise in how to deal with that. *Waterworld* was a prototype in that nothing like it had ever been done before. In many respects, we were pioneers.”

Waterworld photographs copyright © 1995 by Universal City Studios. All rights reserved. Production unit still photography by Ben Glass. Additional photography and artwork courtesy of Cinesite, Boss Film Studios, Rhythm & Hues, Steve Burg, Mark Stetson, David Freund and Dave Fulton. Special thanks to Jim Chaparas, Bette Einbinder, Jennifer Kissell, Suzanne Datz and Angela Gaspar.

OPERATION DUMBO DROP: PACHYDERMS AND PARACHUTES

article by Estelle Shay

Boasting an eight-thousand-pound elephant as its protagonist, Walt Disney Pictures' summer comedy-adventure *Operation Dumbo Drop* required special effects of similarly gargantuan proportions. The film – based on an anecdote that sprang from the war in Vietnam – recounts an unusual mission undertaken by a group of Green Berets stationed there in 1968.

To appease the Montagnard villagers of Dak Nhe after their prized elephant is killed during a firefight between U.S. and Viet Cong forces, the Green Berets promise to deliver a replacement in time for an upcoming ceremonial holiday. In an endearing elephant named Bo-Tat, the soldiers find their substitute. When an attempt to transport the beast through two hundred miles of jungle goes hopelessly awry, the GIs hatch an outrageous plan to meet the deadline by parachute-dropping the elephant to the village below.

Although a trained, twenty-six-year-old Asian elephant named Tai was used throughout the film to portray Bo-Tat, for obvious reasons the parachute drop and landing could not be done with a real animal. To accomplish those scenes, director Simon Wincer and effects supervisor Michael Lessa turned to animatronics expert Rick Lazzarini and his Character Shop crew. “We were commissioned to build eight life-size Tai replicas,” said Lazzarini, who assembled a crew of forty to tackle the task. Early on, Character Shop team leaders visited Tai’s trainer, Gary Johnson, at his San Bernardino elephant farm, Have Trunk Will Travel, to gather data on their subject. “We compiled an extensive list of measurements, using charts and grids to record our information. We also built a pair of seven-foot-tall calipers out of plywood so that four guys could go in and measure Tai’s breadth or the height of her tummy.” Measurements were supplemented with photos and video – and molds taken from the elephant’s skin provided texture reference. Back at the shop, team members commenced work on two fully animatronic elephants required for closeups during the parachute drop. “We were not really sure going into this project how our animatronic would be filmed,” Lazzarini remarked. “Our worst-case scenario was that it might be used in free fall. That was the main reason we needed a spare – in case something happened to the rig as a result of a fall.”

For both hero and backup versions, a jointed steel and aluminum armature – constructed by Gil Correa, Jim Kundig and Brian Simpson – served as a skeleton capable of supporting hundreds of pounds of clay during the initial sculpting phase. “Everything was constructed so that it could be disassembled,” Lazzarini explained. “We could take the head, the ears or the trunk off and work on them separately. The body, legs and tail could also be removed, then plugged back into sockets.” To create the bulk of the sculpture, green foam was applied to the armature



For a scene in *Operation Dumbo Drop* in which an elephant is parachuted out of an airplane, The Character

and covered in a water-based clay. Head sculptor Bob Clark and a team of twelve took four weeks to complete the job. “I had to keep rotating the sculptors around so that their different interpretations would all homogenize,” Lazzarini said. “After the sculpture was done, we made a full-size brush-up silicone mold of the body, a fiberglass mold of the trunk, and a silicone and fiberglass jacket mold of the head.” Skins for the body, legs and head were cast in polyurethane foam with latex skins, while eye area inserts, ears, neck and trunk were cast in foam latex for better flexibility and stretch. “The neck, in particular, had to be extremely flexible. Even foam latex wouldn’t stretch and give as much as we needed, so we had to doctor it up and hand-construct other materials to use in that area.”

Shop created eight life-size replicas – two of which were fully animatronic.

Completed skins were applied to the armature, over a fiberglass core created by G&D Fiberglass of Sun Valley, then painted by Erik Schaper and his crew to match Tai. Since the head and back of the real elephant were extremely hairy, thousands of fake hairs had to be individually hand-punched into the skins. “We contacted broom companies in search of something that would match the thickness and wiriness of elephant hair,” said Lazzarini. “Debra Galvez finally found a natural cactus fiber called tampico that is used in making brooms. For the tail hair we used a much thicker, extruded nylon bristle commonly found in push brooms.” As the Character Shop artists finessed their work on the elephant’s exterior, the mechanical department faced the engineering challenges inherent in producing an eighteen-hundred-pound mechanical puppet. Housed within the armature were the complex mechanics required for more than thirty points of movement, including head, eye and brow articulation, flapping ears and a swishing tail. The trunk, designed by Rick Galinson, was a five-way, segmented vertebrae-type device capable of up-and-down movement at its base, plus prehensile movements – such as S-curve and curling – at the tip.

To articulate the rig, Lazzarini searched for a computer system that would enable his team to program movements and then play them back with reliability. “After checking out several systems, we had Tim Lewis put together a custom-configured, component-based Gilderfluke system that could operate running servos in a programmed sequence. With specific amounts of memory, we could get sixteen minutes of playback.”

Electrical actuators, powered by a gasoline generator, were utilized in pairs for up-and-down head movement, and singly for all other head and trunk maneuvers. “The linear actuators are like giant servos that can move 125 pounds relatively quickly. With the actuators, control boxes and generator

located inside the elephant, there was no room for the computer; so we laid that out in a flat box on the floor of the pallet the animatronic elephant was on, then ran control wires up through the leg to the actuators. When we wanted to start the generator, all we had to do was open up a flap in the



At Buena Vista Visual Effects, bluescreen footage of the live elephant was match-moved and composited into aerial background plates, then enhanced with digital parachute lines.

butt, hit the choke and pull the start cord. The exhaust pipe curled around the inside and came out the rear.”

Incorporated in the legs of the animatronic were Ford truck coil springs to provide shock absorbency and a life-like bounce. Unlike the hero version, the legs of the spare animatronic were equipped with an active hydraulic system that could produce a controlled swaying movement of the entire elephant – a feature that came in handy for a scene in which the airborne Bo-Tat is nearly ejected from a transport plane by panicked pilots after her tranquilizer wears off. The spare animatronic was used during filming of the sequence on a gimbaled plane in Valencia.

Six lighter-weight, static replicas, consisting primarily of fiberglass shells, were built for scenes of the elephant in free fall. To create a sense of movement, the dummy elephants were equipped with flexible polyurethane foam ears, trunks and tails that would ‘wiggle and jiggle’ of their own accord as the elephant fell.

Following a three-month construction period, all of the replicas except the backup animatronic were shipped to Mae Hong Son in northern Thailand for location shooting, accompanied by Lazzarini and five members of his crew, including Bill Zahn and Scott Tebeau. “The shipping didn’t stand the elephants in good stead,” recalled Lazzarini, “so when we got there we had to set up shop and do some repairs. We also had to darken the skins with charcoal to match Tai, who had been made up to look more like the darker Indian stunt doubles. Erik Schaper’s beautiful paint job kind of got lost in the wash.”

For landing shots where the skydiving Bo-Tat descends upon the village, parachute riggers constructed a huge aluminum pallet and enclosure, with the life-size animatronic bolted in place. The entire construct was then tethered to a crane and hoisted into the air. Puppeteering, by Lazzarini and his crew, was accomplished using remote control joysticks and a waldo designed specifically for the job. Performance moves were programmed into the animatronic’s on-board computer.

Aerial shooting was executed by second unit director Billy Burton in the city of Chiang-Mai. All six fiberglass elephants were pressed into action to film wide shots of the free-fall sequence. One by one, the fiberglass stand-ins were strapped to a parachute rigged to open automatically, then dropped from a helicopter at heights ranging from eight thousand to ten thousand feet. The rigging was not always foolproof. “Three out of the six elephants actually crashed to the ground, not to be resurrected,” observed Lazzarini. “After a while, we were kind of cheering the crashes on. We were constantly having to go in and make cosmetic repairs on these things with spray adhesive and charcoal – so when they crashed, it was like, ‘Well, that’s one less elephant we have to keep painting!’” Fortunately for the production, eighteen drops made over an eight-day period produced a number of successful runs; and the desired shots were captured on film.

Supplementing Lazzarini’s practical effects were bluescreen shots of the real elephant being boarded on the C-123, hoisted out the back of the plane, then free-falling and drifting down after her parachute opens. “The film couldn’t just stay on the fiberglass replica falling through the sky,” said Mike Lessa of Buena Vista Visual Effects, charged with *Operation Dumbo Drop*’s bluescreen work and digital compositing. “To make those shots tie in, we needed closeups of the live animal moving and acting and looking around.”

For the initial shot of Tai entering the aircraft, the C-123 was modified by Howard Jensen's practical effects team. "Tai wouldn't fit inside the real airplane," recalled Lessa, "so Howard and his crew lowered the floor of the plane by two feet." Shots of the elephant being hoisted out of the plane on a cable and winch were filmed bluescreen. "We had to shoot the element of Tai sliding out the back of the plane bluescreen because we felt it was too dangerous for her. We didn't want to scare her in any way; so we filmed one element that consisted of the actors standing inside the plane, with bluescreen out the back. That was composited with a shot of Tai in her flying rig." The following shot, a brief wide angle of the elephant and crate actually falling from the plane, was a CGI image created by digital artist Aaron Campbell. "We needed to show more pitching and rolling than we could get with just a bluescreen setup."

Subsequent bluescreen shots of the elephant falling were accomplished with the aid of a special flying rig, built specifically for the jumbo-size performer. "Initially, Tai was fearful of being lifted up by her crate when the cables were on either side of her," recalled Lessa. "If she was even a foot off the ground, she would shift and it would start swinging all over the place." To minimize the animal's fear, Howard Jensen's team constructed a huge I-beam rig that extended out ten feet from the crate in all directions. "It had cross-bracing and posts coming up so that the pick points for the wires were several feet away from the elephant. All four points were attached to a crane; and when we lifted her straight up in that contraption, she was absolutely rock solid. Once she felt safe, it became fun for her and she would actually rock the crate back and forth. With the camera mounted on a crane, panning and tilting and moving around her as she rocked, we could make it look as if the crate was tipping and swaying as it fell through the sky." The rig was also used for bluescreen shots of the elephant floating earthward after the deployment of the parachute. Such shots were finished off with computer generated parachute lines.

The biggest challenge of the show for Lessa was compositing all of the bluescreen elephant footage with the live-action aerial plates shot in Thailand. "In quite a few cases, a perfect background did not exist for these shots. The vast majority of the backgrounds were created by stitching together several different live-action plates. That gave us virtually endless panoramas, and enabled us to add overriding moves to the backgrounds and not be stuck with the format of the original photography. After we pieced together the appropriate background, we either had to track it and apply that move to the elephant, or – in most cases – track the elephant move first to stabilize it, then add that move to the background so that the two would fly together." In total, BVVE composited ninety visual effects shots, seventy of which ended up in the final cut of the film.

Just as the original incident that inspired the movie had presented enormous challenges to a small group of soldiers, *Operation Dumbo Drop* tested the resourcefulness of everyone involved in its making. "An undertaking as massive as this one makes others pale by comparison," remarked Lazzarini. "It was quite a test for me and my crew. We had to design and build these huge animals, engineer them in such a way that they were self-contained, figure out how they were going to fall, then get them to a Third World country. Having done all of those things successfully, I find I don't get as stressed out on other projects now. It has made me a lot more confident. When I say our shop will deliver something, it's going to deliver."